EMISSIONS TEST RESULTS
AT COMPRESSOR STATION 6, UNIT A
NEAR ROSALIA, WASHINGTON

Prepared For:

PACIFIC GAS TRANSMISSION COMPANY

Prepared By:

Kevin C. Hopkins

CARNOT
Tustin, California

JANUARY, 1991

CR 82100-2265R

REPORT CERTIFICATION

The sampling and analysis performed for this report was carried out under my direction and supervision.

Date 1/18/91

Kevin C. Hopkins
Senior Engineer

I have reviewed all testing details and results in this test report and hereby certify that the test report is authentic and accurate.

Date 1/18/91

Kevin C. Hopkins
Senior Engineer

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SECTION 1.0

INTRODUCTION AND SUMMARY

Carnot was contracted by Pacific Gas Transmission (PGT) Company to conduct an emissions test of its natural gas fired turbine at Compression Station 6 Unit A, near Rosalia, Washington. The tests were conducted to comply with the requirements of the Spokane County Air Pollution Control Authority.

This document presents the test results for the 1990 annual compliance tests at Compressor Station 6, Unit A. All tests were performed with the turbine operating at full load. Table 1-1 presents a summary of the three tests.

The tests were performed by Kevin Hopkins and Mike Schmidt of Carnot. Unit operations were coordinated by Carmen Acton of PGT.

TABLE 1-1
RESULTS SUMMARY - PGT STATION 6 UNIT A

	5-6A	6-6A	7-6A	Average
Test No.	12/10/90	12/10/90	12/10/90	——
Date	1105/1205	1220/1320	1335/1445	——
Time				
Fuel Flow, scfh	109,300	110,500	110,240	110,013
Exhaust, °F	947	946	945	946
Turbine Inlet,°F	1375	1375	1375	1375
Gas Producer Speed, %	102	102	102	102
rpm	11,076	11,091	11,100	11,089
Gas Producer Compressor Discharge,psi	203	203	203	203
Barometric Pressure, in Hg	27.66	27.66	27.63	27.65
Wet Bulb, °F	43.8	43.5	43.0	43.4
Dry Bulb, °F	45.5	44.0	43.5	44.3
Humidity, lb H_2O/lb dry air	0.0057	0.0059	0.0058	0.0058
ISO Factor	1.0700	1.0790	1.0792	1.0761
O_2, %	15.28	15.30	15.33	15.30
CO_2, %	3.00	3.00	3.00	3.00
Exhaust Flow, dscfm*	58,690	59,550	59,730	59,320
Exhaust Flow, dscfm**	62,100	62,780	62,630	62,530
NO_x, ppm	162.0	161.6	162.9	162.2
ppm @ 15% O_2	170.1	170.3	172.5	171.0
ppm ISO @ 15% O_2	182.0	183.8	186.2	184.0
lb/hr+	69.15	69.99	70.76	69.97
lb/hr++	73.17	73.79	74.20	73.72
CO, ppm	1	1	1	1
ppm @ 15% O_2	1	1	1	1
lb/hr+	0.26	0.26	0.26	0.26
lb/hr++	0.28	0.27	0.27	0.27
SO_2, ppm	0.00	0.00	0.00	0.00
ppm @ 15% O_2	0.00	0.00	0.00	0.00
lb/hr+	0.00	0.00	0.00	0.00

* Exhaust flows are calculated using the measured fuel flow and the EPA O_2 based emission factor.

** Exhaust flows are calculated using the measured fuel flow and the EPA CO_2 based emission factor.

+ Mass emissions rates are calculated using the exhaust flow rate based on the O_2 F-Factor and the measured species concentration.

++ Mass emissions rates are calculated using the exhaust flow rate based on CO_2 F-Factor and the measured species concentration.

SECTION 2.0

UNIT DESCRIPTION

PGT Compressor Station 6, Unit A is a Solar Mars gas turbine engine which is rated at 14,600 hp (ISO).

The following operating parameters were recorded at 15 minute intervals during each test:

- Fuel flow rate
- Exhaust temperature
- Gas producer speed (NGP)
- Gas producer compressor discharge pressure (PCP)
- Power turbine inlet temperature (T-5)
- Inlet pressure

Data sheets documenting unit operation are provided in Appendix D of this report.

SECTION 3.0

TEST DESCRIPTION

3.1 TEST CONDITIONS

Table 3-1 presents the average test conditions during the tests. Also shown are the average ambient conditions.

3.2 SAMPLE LOCATION

Pacific Gas Transmission Company Compressor Station 6, Unit A, near Rosalia, Washington, is a Solar gas turbine which exhausts to a stack which measured 7'3" by 7'3". The sample plane was located two equivalent duct diameters downstream of a 90° bend, and approximately 1.5 duct diameters upstream of the stack exit. A sketch of the sample location is provided in Appendix C.

3.3 TEST PROCEDURES

Test procedures used at Compressor Station 6 are presented in Table 3-2. Detailed test methods can be found in Appendix A. Modifications to standard procedures are discussed in the following sections.

3.3.1 Preliminary Diluent Traverse

In accordance with EPA Method 20, a preliminary diluent traverse was performed in order to select sample points for subsequent tests. A 30-point grid was traversed at two minutes per point. Neither O_2 nor CO_2 varied by more than 1% of the overall average, indicating a well-mixed exhaust flow. For the three remaining tests, the probe was placed at port D point number 4.

3.3.2 NOx, CO, O_2, SO_2, and CO_2 Measurements

NOx, CO, O_2, and CO_2 measurements were made at full load. Triplicate 60-minute runs were performed.

SO_2 emissions were calculated based on a fuel sulfur analysis, performed by Truesdail Laboratories in Irvine California.

TABLE 3-1
SUMMARY OF TEST CONDITIONS

Fuel Flow	110,013 scfh
Exhaust Temperature	946 °F
Turbine Inlet, °F	1375 °F
Gas Producer Speed	102 %
Gas Producer Speed	11089 rpm
Compressor Discharge	203 psi
Barometric pressure	27.65 in Hg
Wet Bulb Temperature	43.4 °F
Dry Bulb Temperature	44.3 °F

3.3.3 Exhaust Gas Flow

Exhaust gas flow was calculated using measured fuel flow, fuel analysis, measured excess O_2, and stoichiometric calculation. Calculation procedures are documented in EPA Method 19. Specific calculations are presented in Appendix E.

3.3.4 Fuel Analysis

Fuel analysis (composition, HHV) for use in stoichiometric flow rate calculations, was performed by Truesdail Laboratories.

Exhaust gas flow was also calculated using measured excess CO_2, measured fuel flow, fuel analysis and stoichiometric calculation.

TABLE 3-2
TEST PROCEDURES

Parameter	Measurement Technique	Reference Method	Comments
NOx	Chemiluminescence	EPA 20	Triplicate 1-hour runs
CO	Nondispersive infrared absorption	EPA 10	Triplicate 1-hour runs
O_2	Electrochemical cell	EPA 20	Triplicate 1-hour runs
SO_2	Fuel Analysis	---	Duplicate fuel samples collected during testing
CO_2	Nondispersive infrared absorption	EPA 3A	Triplicate 1-hour runs
Exhaust gas flow rate	Fuel flow measurement and stoichiometric calculation	EPA 19	

SECTION 4.0

RESULTS

The results of the compliance tests are presented in Table 4-1A, 4-1B and 4-2. Tables 4-1A and 4-1B provide the results of the fuel analysis. Table 4-2 presents the results summary.

Raw data and calculation procedures can be found in Appendix C, D, E and F of this report.

TABLE 4-1A

NATURAL GAS ANALYSIS

Species	% Volume
O_2	0.0
N_2	0.0
CH_4	97.3
CO_2	0.4
C_2H_6	2.0
C_3H_3	0.2
n-C_4H_{10}	ND
i-C_4H_{10}	ND
He	ND
H_2S	<0.1ppm

ND - Not Detected

TABLE 4-1B
NATURAL GAS ANALYSIS

HHV, Btu/Scf	1,025
HHV, Btu/lb	23,673
Density, lb/scf	0.0433
Molecular Weight, lb/lb-mole	16.43
EPA F-Factor, DSCF/MMBtu @ 60 °F	
O_2 Based:	8,453
CO_2 Based:	998

TABLE 4-2
RESULTS SUMMARY - PGT STATION 6 UNIT A

	5-6A	6-6A	7-6A	Average
Test No.	12/10/90	12/10/90	12/10/90	——
Date	1105/1205	1220/1320	1335/1445	——
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Fuel Flow, scfh	109,300	110,500	110,240	110,013
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Barometric Pressure, in Hg	27.66	27.66	27.63	27.65
Wet Bulb, °F	43.8	43.5	43.0	43.4
Dry Bulb, °F	45.5	44.0	43.5	44.3
Humidity, lb H_2O/lb dry air	0.0057	0.0059	0.0058	0.0058
ISO Factor	1.0700	1.0790	1.0792	1.0761
O_2, %	15.28	15.30	15.33	15.30
CO_2, %	3.00	3.00	3.00	3.00
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NO_x, ppm	162.0	161.6	162.9	162.2
ppm @ 15% O_2	170.1	170.3	172.5	171.0
ppm ISO @ 15% O_2	182.0	183.8	186.2	184.0
lb/hr+	69.15	69.99	70.76	69.97
lb/hr++	73.17	73.79	74.20	73.72
CO, ppm	1	1	1	1
ppm @ 15% O_2	1	1	1	1
lb/hr+	0.26	0.26	0.26	0.26
lb/hr++	0.28	0.27	0.27	0.27
SO_2, ppm	0.00	0.00	0.00	0.00
ppm @ 15% O_2	0.00	0.00	0.00	0.00
lb/hr+	0.00	0.00	0.00	0.00

* Exhaust flows are calculated using the measured fuel flow and the EPA O_2 based emission factor.

** Exhaust flows are calculated using the measured fuel flow and the EPA CO_2 based emission factor.

+ Mass emissions rates are calculated using the exhaust flow rate based on the O_2 F-Factor and the measured species concentration.

++ Mass emissions rates are calculated using the exhaust flow rate based on the CO_2 F-Factor and the measured species concentration.

APPENDIX A

MEASUREMENT PROCEDURES

Extractive Continuous Emissions Monitoring System

Oxygen (O_2) by Continuous Analyzer

NO/NOx by Continuous Analyzer

Carbon Monoxide (CO) by NDIR/Gas Filter Correlation

Extractive Continuous Emissions Monitoring System

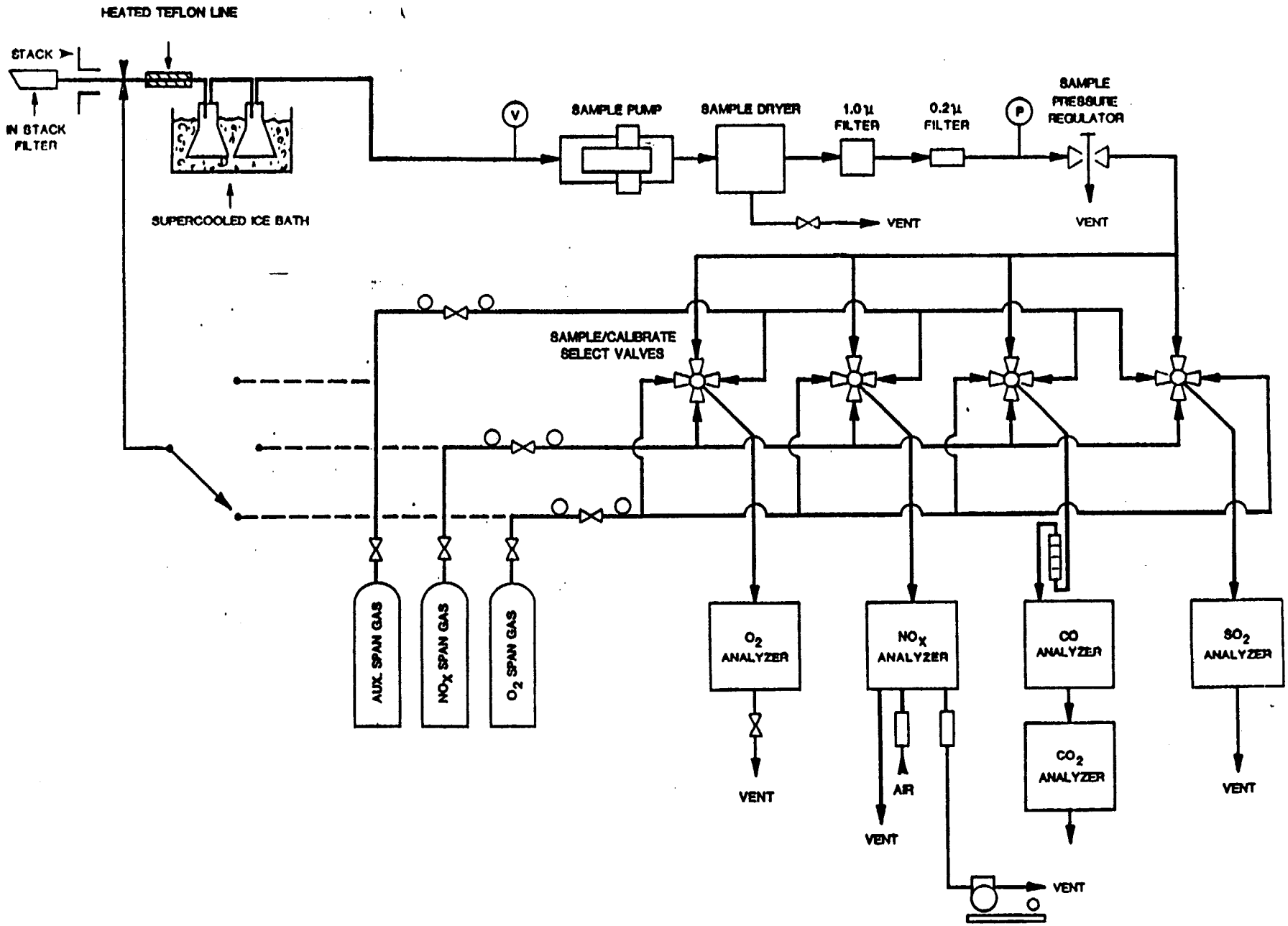
O_2, CO, CO_2, NO, and NOx are measured using an extractive continuous emissions monitoring (CEM) package, shown in the following figure. This package is comprised of three basic subsystems. They are: (1) the sample acquisition and conditioning system, (2) the calibration gas system, and (3) the analyzers themselves. This section presents a description of the sampling and calibration systems. Descriptions of the analyzers used in this program and the corresponding reference test methods follow. Information regarding quality assurance information on the system, including calibration routines and system performance data follows.

The sample acquisition and conditioning system contains components to extract a representative sample from the stack or flue, transport the sample to the analyzers, and remove moisture and particulate material from the sample. In addition to performing the tasks above, the system must preserve the measured species and deliver the sample for analysis intact. The sample acquisition system extracts the sample through a stainless steel probe. The probe is insulated or heated as necessary to avoid condensation.

Where water soluble NO_2 and/or SO_2 are to be measured, the sample is drawn from the probe through a heated Teflon sample line into a supercooled (approximately -20 C) water removal trap. The trap consists of stainless steel flasks in a bath of dry ice and antifreeze. If dry ice is not locally available, ice and rock salt are used. This design removes the water vapor by condensation and freezes the liquid quickly. The contact between the sample and liquid water is minimized. Since the solubility of the NO_2 and SO_2 in ice is negligible, these species are conserved. This system meets the requirements of EPA Method 20. The sample is then drawn through a Teflon transport line and particulate filter, into the sample pump. The pump is a dual head, diaphragm pump. All sample-wetted components of the pump are stainless steel or Teflon. The pressurized sample leaving the pump flows through a stainless steel refrigerated (38 F) compressed air dryer for final moisture removal. A drain line and valve are provided to constantly expel any condensed moisture from the dryer. After the dryer, the sample is directed into a distribution manifold. Excess sample is vented through a back-pressure regulator, maintaining a constant pressure of 5-6 psig to the analyzers.

The calibration system is comprised of two parts: the analyzer calibration, and the system bias check (dynamic calibration). The analyzer calibration equipment includes pressurized cylinders of certified span gas. The gases used are, as a minimum, certified to 1% by the manufacturer where necessary, to comply with reference method requirements. EPA Protocol 1 gases are used. The cylinders are equipped with pressure regulators which supply the calibration gas to the analyzers at the same pressure and flow rate as the sample. The selection of zero, span, or sample gas directed to each analyzer is accomplished by operation of the sample/calibration selector valves.

The system bias check is accomplished by transporting the same gases used to zero and span the analyzers to the sample conditioner inlet (probe exit). The span gas is exposed to the same elements as the sample and the system response is documented. Where the supercooled moisture removal system is used, water is added to the knockout flasks before the pre-test check. The analyzer indications for the system calibration check must agree within 5% of the analyzer calibration. Values are adjusted and changes/repairs are made to the system to compensate for any difference in analyzer readings. Specific information on the analytical equipment and test methods used is provided in the following pages.



Extractive Continuous Emissions Monitoring System

Method:	Oxygen (O_2) by Continuous Analyzer
Applicable Ref. Methods:	EPA 3A, EPA 20, ARB 100, BA ST-14
Principle:	A sample is continuously drawn from the flue gas stream, conditioned, and conveyed to the instrument for direct readout of O_2 concentration.
Analyzer:	Teledyne Model 326A
Measurement Principle:	Electrochemical cell
Ranges:	0-5, 0-10, 0-25% O_2
Accuracy:	1% of full scale
Output:	0-100 mV, linear
Interferences:	Halogens and halogenated compounds will cause a positive interference. Acid gases will consume the fuel cell and cause a slow calibration drift.
Response Time:	90% <7 seconds
Sampling Procedure	The stack dimensions are described in Section 3.2. A 5 x 6 matrix will be used as specified in EPA Method 20 for a preliminary O_2 traverse. Subsequent tests will be performed using the eight sample points with the lowest O_2 level. A representative flue gas sample is collected and conditioned using the CEM system described previously.
Analytical Procedure:	An electrochemical cell is used to measure O_2 concentration. Oxygen in the flue gas diffuses through a Teflon membrane and is reduced on the surface of the cathode. A corresponding oxidation occurs at the anode internally, and an electric current is produced that is proportional to the concentration of oxygen. This current is measured and conditioned by the instrument's electronic circuitry to give an output in percent O_2 by volume.
Special Calibration Procedure:	The measurement cells used with the O_2 instrument have to be replaced on a regular basis. After extended use, the cell tend to produce a nonlinear response. Therefore, a three-point calibration is performed at the start of each test day to check for linearity. If the response is not linear ($\pm$ 2% of scale), the cell is replaced.

Method:	NO/NOx by Continuous Analyzer
Applicable Ref. Methods:	EPA 7E, EPA 20; ARB 100, BA ST-13A
Principle:	A sample is continuously drawn from the flue gas stream, conditioned, and conveyed to the instrument for direct readout of NO or NOx.
Analyzer:	Teco Model No. 10AR
Measurement Principle:	Chemiluminescence
Accuracy:	1% of full scale
Ranges:	0-2.5, 0-10, 0-25, 0-100, 0-250, 0-1000, 0-2500, 0-10,000 ppm
Output:	0-10 mV
Inferences:	Compounds containing nitrogen (other than ammonia) may cause interference.
Response Time:	90%, 1.5 seconds (NO mode) and 1.7 seconds (NOx mode)
Sampling Procedure:	A representative flue gas sample is collected and conditioned using the CEM system described previously. Method 20 procedures for selecting sample points are used.
Analytical Procedure:	The oxides of nitrogen monitoring instrument is a chemiluminescent nitric oxide analyzer. The operational basis of the instrument is the chemiluminescent reaction of NO and ozone (O_3) to form NO_2 in an excited state. Light emission results when excited NO_2 molecules revert to their ground state. The resulting chemiluminescence is monitored through an optical filter by a high sensitivity photomultiplier tube, the output of which is electronically processed so it is linearly proportional to the NO concentration. The output of the instrument is in ppmV. When NO_2 is expected to be present in the flue gas, a supercooled water dropout flask will be placed in the sample line to avoid loss of NO_2. Since NO_2 is highly soluble in water, "freezing out" the water will allow the NO_2 to reach the analyzers for analysis. The analyzer measures NO only. In the NOx mode, the gas is passed through a moly converter which converts NO_2 to NO and a total NOx measurement is obtained. NO2 is determined as the difference between NO and NOx. Use of a moly converter instead of a stainless steel converter eliminates NH_3 interference; NH_3 is converted to NO with a stainless converter, but not with a moly converter.

Method:	Carbon Monoxide (CO) by NDIR/Gas Filter Correlation
Applicable Ref. Methods:	EPA 10; ARB 1-100; BA ST-6
Principle:	A sample is continuously drawn from the flue gas stream, conditioned, and conveyed to the instrument for direct readout of CO concentration.
Analyzer:	TECO, Model 48
Measurement Principle:	NDIR/Gas Filter Correlation
Precision:	0.1% ppm
Ranges:	0-5, 0-10, 0-25, 0-50, 0-100, 0-250, 0-500, 0-1000, 0-5000 ppm
Output:	0-100 mV
Interferences:	Negligible interference from water and CO_2
Rise/Fall Times (0-95%)	1 minute @ 1 lpm flow, 30 second integration time
Sampling Procedure:	A representative flue gas sample is collected and conditioned using the CEM system described previously. Sample point selection has been described previously.
Analytical Procedure:	Radiation from an infrared source is chopped and then passed through a gas filter which alternates between CO and N_2 due to rotation of a filter wheel. The radiation then passes through a narrow band-pass filter and a multiple optical pass sample cell where absorption by the sample gas occurs. The IR radiation exits the sample cell and falls on a solid state IR detector.

APPENDIX B

QUALITY ASSURANCE

Appendix B.1

Quality Assurance Program Summary

QUALITY ASSURANCE PROGRAM SUMMARY

Carnot ensures the quality and validity of its emission measurement and reporting procedures through a rigorous quality assurance (QA) program. The program is developed and administered by an internal QA Officer, and encompasses seven major areas:

1. Development and use of an internal QA manual.
2. QA reviews of reports, laboratory work, and field testing.
3. Equipment calibration and maintenance.
4. Chain of custody.
5. Training.
6. Knowledge of current test methods.
7. Agency certification.

Each of these areas is discussed individually below.

Quality Assurance Manual. Carnot has prepared a QA Manual according to EPA guidelines. The manual serves to document and formalize all of Carnot's QA efforts. The manual is constantly updated, and each member of the Source Test Division is required to read and understand its contents. The manual includes details on the other six QA areas discussed below.

QA Reviews. Carnot's review procedure includes review of each source test report by the QA Officer, and spot check reviews of laboratory and field work.

The most important review is the one that takes place before a test program begins. The QA Officer works closely with Source Test Division personnel to prepare and review test protocols. Test protocol review includes selection of appropriate test procedures, evaluation of any interferences or other restrictions that might preclude use of standard test procedures, and evaluation and/or development of alternate procedures.

Equipment Calibration and Maintenance. The equipment used to conduct the emissions measurements is maintained according to the manufacturer's instructions to ensure proper operation. In addition to the maintenance program, calibrations are carried out on each measurement device according to the schedule outlined by the California Air Resources Board (CARB). The schedule for maintenance and calibrations are given in Tables B-1 and B-2. Quality control checks are also conducted in the field for each test program. The following is a partial list of checks made as part of each CEM system test series.

Sample acquisition and conditioning system leak check.

2-point analyzer calibrations (all analyzers)

3-point analyzer calibrations (analyzers with potential for linearity errors).

Complete system calibration check ("dynamic calibration" through entire sample system).

Periodic analyzer calibration checks (once per hour) are conducted at the start and end of each test run. Any change between pre- and post-test readings are recorded.

TABLE B-1.
SAMPLING INSTRUMENTS AND EQUIPMENT CALIBRATION SCHEDULE

Instrument Type	Frequency of Calibration	Standard of Comparison or Method of Calibration	Acceptance Limits
Orifice Meter (large)	12 months	Calibrated dry test meter	±2% of volume measured
Dry Gas Meter	12 months or when repaired	Calibrated dry test meter	±2% of volume measured
S-Type Pitot (for use with EPA type sampling train)	6 months	EPA Method 2	Cp constant (+5%) over working range. Difference between the average Cp for each leg must be less than 2%
Vacuum Gauges Pressure Gauges	6 months	Manometer	±3%
Field Barometer	6 months	Mercury barometer	± 0.2" Hg
Temperature Measurement	6 months	NBS mercury thermometer or NBS calibrated platinum RTD	± 4 F for <400°F ± 1.5% for >400°F
Temperature Readout Devices	6 months	Precision potentiometer	± 2% full scale reading
Analytical Balance	12 months (checked prior to each use)	Should be performed by manufacturer or qualified laboratory	± 0.3 mg of stated weight
Probe Nozzles	12 months	Nozzle diameter check micrometer	Range <± 0.10 mm for three measurements
Continuous Analyzers	Depends on use, frequency, and performance	As specified by manufacturers operating manuals, EPA NBS gases, and/ or ref. methods	Satisfy all limits specified in operating specifications

TABLE B-2.
EQUIPMENT MAINTENANCE SCHEDULE
Based on Manufacturer's Specifications
and Carnot Experience

Equipment	Performance Requirement	Maintenance Interval	Corrective Action
Pumps	1. Absence of leaks 2. Ability to draw mfr required vacuum and flow	Every 500 hrs of operation or 6 months whichever is less	1. Visual insp. 2. Clean 3. Replace worn parts 4. Leak check
Flow Measuring Device	1. Free mechanical movement 2. Absence of malfunction	Every 500 hrs of operation or 6 months whichever is less After each test, if used in H_2S sampling or other corrosive atmospheres	1. Visual insp. 2. Clean 3. Calibrate
Sampling Instruments	1. Absence of malfunction 2. Proper response to zero, span gas	As required by manufacturer	As recommended by manufacturer
Integrated Sampling Tanks	Absence of leaks	Depends on nature of use	1. Steam clean 2. Leak check
Mobile Van Sampling Systems	Absence of leaks	Depends on nature of use	1. Change filters 2. Change gas dryer 3. Leak check 4. Check for system contamination
Sampling Lines	Sample degradation less than two percent	After each test or test series	Blow filtered air thru line until dry

All calibrations are conducted using gases certified by the manufacturer to be + 1% of label value (NBS traceable).

Calibration and CEM performance data are fully documented, and are included in each source test report.

Chain of Custody. Carnot maintains full chain of custody documentation on all samples and data sheets. In addition to normal documentation of changes between field sample custodians, laboratory personnel, and field test personnel, Carnot documents every individual who handles any test component in the field (e.g., probe wash, impinger loading and recovery, filter loading and recovery, etc.).

Samples are stored in a locked area to which only Source Test Division personnel have access. Neither other Carnot employees nor cleaning crews have keys to this area.

Data sheets are copied immediately upon return from the field, and this first generation copy is placed in locked storage. Any notes made on original sheets are initialed and dated.

Training. Personnel training is essential to ensure quality testing. Carnot has formal and informal training programs which include:

1. Attendance at EPA-sponsored training courses.
2. Enrollment in EPA correspondence courses.
3. A requirement for all technicians to read and understand Carnot's QA Manual.
4. In-house training and QA meetings on a regular basis.
5. Maintenance of training records.

Knowledge of Current Test Methods. With the constant updating of standard test methods and the wide variety of emerging test methods, it is essential that any qualified source tester keep abreast of new developments. Carnot subscribes to services which provide updates on EPA and CARB reference methods, and on EPA, CARB, and SCAQMD rules and regulations. Additionally, source test personnel regularly attend and present papers at testing and emission-related seminars and conferences. Carnot personnel maintain membership in the Air Pollution Control Association, the Source Evaluation Society, and the ASME Environmental Control Division.

Appendix B.2

Equipment Calibration

SPAN GAS RECORD

Date 12/9/90

Client/Location PGT Station 6 Unit A

By _____

Gas	Span Cylinder		Aux. Span Cylinder	
	Cylinder No.	Concentration	Cylinder No.	Concentration
Zero	AAL-681	N_2	—	—
NOx	ALM-2854	146.4 ppm	ALM-7351	229.8 ppm
O2	ALM-11553	8.00%	ALM-14399	12.49%
CO	ALM-12686	55.84 ppm	ALM-5658	88.25 ppm
CO2	ALM-11553	22.51 ppm	ALM-14349	14.95%
SO2				

INSTRUMENT LINEARITY

	Analyzer				
	O2	CO2	~~CO~~ NOx	~~NOx~~ CO	SO2
Analyzer Range	25%	25%	250 ppm	100 ppm	
Set to ~~High~~ STD MID (80-90% of Range)	8.00%	High 22.5%	145.0 ppm	High CO ~~55.8 ppm~~	
As-Found ~~Low~~ High STD (50-60% of Range)	12.63%	14.75%	230.0 ppm	54.5 ppm	
Actual Value of Low STD	12.49%	14.95%	229.8 ppm	55.8 ppm	
Difference in % of ~~Full Scale~~ Range	+1.1%	-1.3%	+0.1%	-2.3%	

Allowable deviation is 2% of full scale (2 squares on strip chart).

FDS-10

CARNOT

CEM PERFORMANCE DATA

By K. Hopkins Location PGT - Station 6 Unit A Date 12/9/96

System Configuration

Analyzers in Service NO_x ($NO + NO_2$), O_2, CO_2, CO

Probe: Length 10' Liner Material S. S. Heated (Y/N) Y

Sample Line: Length 150' Material Teflon

On-Stack Conditioner: In Service (Y/N) Y Coolant ICE

System Flow Rate (from file): _____ cfm

System Leak Check

Pre-Test: 0.00 cfh Post-Test: _____ cfh

$$\text{Leak Rate (\%)} = \frac{\text{Post Test (cfh)}}{\text{System Flow Rate (cfm)} \times 60} \times 100 = \_\_\_\_\_ \%$$

System Response Time Check

	1	2	3	Avg
Upscale	30 sec	25 sec	sec	30 sec
Downscale	30 sec	30 sec	sec	30 sec

Scott Specialty Gases, Inc.

FAX: 714-887-0549
PHONE: 714-887-2571

2600 CAJON BLVD., SAN BERNARDINO, CA 92405

Shipped From: Scott SAN BERNARDINO,
Date Shipped 11/12/90
Our Project No: 10003
Your P.O. No: 6693
Page 1 of 1
Expiration Date: 5/92

CARNOT
15991 RED HILL AVE, SUITE 110
TUSTIN, CA 92680
JIM MULLIGAN

CERTIFICATE OF ANALYSIS – EPA PROTOCOL GASES*

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. ALM-2854 Cylinder Pressure 1900 psig Certified Accuracy ±1% NIST Traceable

COMPONENTS	CERTIFIED CONC	REFERENCE STD SRM/CRM NO.	REFERENCE STD CYL. NO.	REFERENCE STD CONC.	GAS ANALYZER MAKE/MODEL/SERIAL NO.	GAS ANALYZER LAST CAL. DATE	GAS ANALYZER ANALYTICAL PRINCIPLE
NITRIC OXIDE	143.5 ppm	CRM16858	CAL-5827	236 ppm	THERMO-ELECTRON	9/3/90	CHEMI-LUMINENSC
NOX	146.4 ppm				10 AR 14853-150		

BALANCE GAS NITROGEN

ANALYZER READINGS: Z = Zero Gas T = Test Gas R = Reference Gas

Component NITRIC OXIDE
First Analysis Date 10/27/90 Units mv

Z 0.00	R 94.40	T 57.26
R 94.10	Z 0.00	T 57.20
Z -0.02	T 57.30	R 94.38

Mean Test Assay 143.3 ppm

Second Analysis Date 11/3/90 Units mv

Z 0.00	R 94.40	T 57.32
R 94.40	Z 0.01	T 57.49
Z 0.00	T 57.48	R 94.44

Mean Test Assay 143.5 ppm

Component _____ Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Component _____ Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Chronology: Date _____
Assay _____

Analyst L. OLDHAM

Approved By: [signature]

Scott Specialty Gases, Inc.
FAX: 714-887-0549
PHONE: 714-887-2571
2600 CAJON BLVD., SAN BERNARDINO, CA 92405

6/15/90

CARNOT
15991 RED HILL AVE
SUITE 110
TUSTIN CA 92680-0000
FORMERLY ENERGY SYS ASSOC

PROJECT #: 02-07371
PO #: 6102

CYLINDER #: ALM011553

ANALYTICAL ACCURACY: +/-1%

COMPONENT	REQUESTED CONCENTRATION		ANALYSIS 1 (MOLES)	U/M
RBON DIOXIDE	22.5	PCT	22.51	PCT
'GEN	8.0	PCT	8.000	PCT
TROGEN	BALANCE	GAS		N/A

NOTES: GRAVIMETRIC MASTER GAS-CERTIFIED TO HAVE BEEN BLENDED AGAINST NIST CERTIFIED WEIGHTS AND VERIFIED TOBE CORRECT BY INDEPEDENT ANALYSIS.
CO2 TRACEABLE TO CRM1675
O2 TRACEABLE TO CRM2658

DATE OF ANALYSIS: 6/15/90

ANALYST: MAYNARD JOHNSON

APPROVED BY: ROBERT SHEALY

Scott Specialty Gases, Inc.

FAX: 714-887-0549
PHONE: 714-887-2571
2600 CAJON BLVD., SAN BERNARDINO, CA 92405

Shipped From: Scott SAN BERNARDINO, CA
Date Shipped 5/24/90
Our Project No: 6490
Your P.O. No: 5923
Page 1 of 1
Expiration Date: 11/91

CARNOT
TUSTIN, CA

CERTIFICATE OF ANALYSIS—EPA PROTOCOL GASES

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. ALM-12686 Cylinder Pressure 1900 psig Certified Accuracy ±1% % NBS Traceable

COMPONENTS	CERTIFIED CONC	REFERENCE STD SRM/CRM NO.	CYL. NO.	CONC.	GAS ANALYZER MAKE/MODEL/SERIAL NO.	LAST CAL. DATE	ANALYTICAL PRINCIPLE
ARBON MONOXIDE	55.84 ppm	GMIS	ALM-7531	258.7 ppm	HORIBA AIA 24	4/30/90	INFRA RED
		TRACEABLE TO CRM2636			4564403		

ALANCE GAS NITROGEN

NALYZER READINGS: Z = Zero Gas T = Test Gas R = Reference Gas

omponent CARBON MONOXIDE
rst Analysis Date 5/15/90 Units ppm

00.0	R	95.0	T	22.9	
95.0	Z	00.0	T	22.9	
00.0	T	22.9	R	95.0	

Mean Test Assay 55.84 ppm

econd Analysis Date 5/22/90 Units ppm

00.0	R	95.0	T	22.9	
95.0	Z	00.0	T	22.9	
00.0	T	22.9	R	95.0	

Mean Test Assay 55.84 ppm

Component ____ Date ____ Units ____

Z	R	T			
R	Z	T			
Z	T	R			

Mean Test Assay ____

Date ____ Units ____

Z	R	T			
R	Z	T			
Z	T	R			

Mean Test Assay ____

Component ____ Date ____ Units ____

Z	R	T			
R	Z	T			
Z	T	R			

Mean Test Assay ____

Date ____ Units ____

Z	R	T			
R	Z	T			
Z	T	R			

Mean Test Assay ____

hronology: Date ____ Assay ____

Analyst P. VILIMAS/M. JOHNSON

Approved By R. S. [illegible]

APPENDIX C

RAW DATA

CARNOT

SAMPLING POINT LOCATION DATA
EPA Method 1

Plant PGT Station 6 Unit A Data by _____

Date _____

Test Location Stack, Solar Mars Turbine

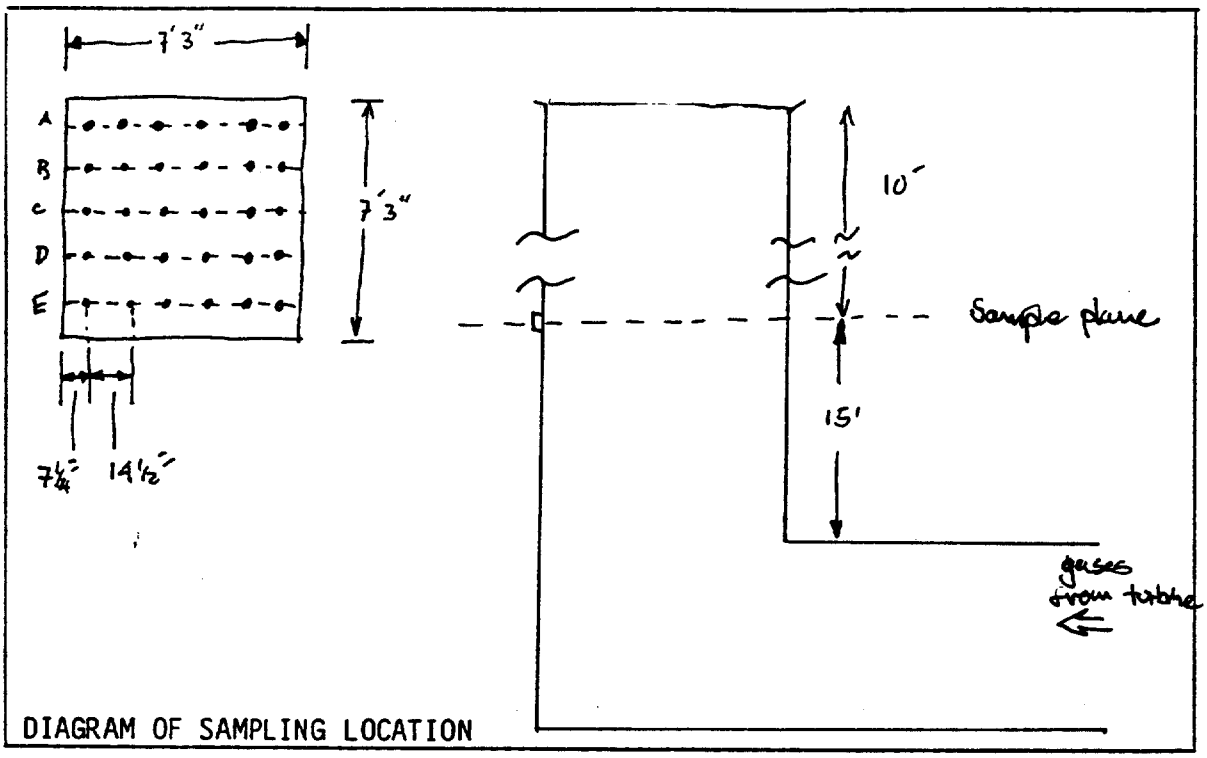


DIAGRAM OF SAMPLING LOCATION

Upstream Dist./Dia. _____
Downstream Dist./Dia. _____
Coupling Length _____
No. of Sampling Pts. _____
Stack Dimension 87" x 87"
Stack Area, ft^2 52.6 ft^2

Sample Point	~~% of Diameter~~	In. from near Wall	In. from Nozzle*
1	7¼"		
2	~~14½~~ 21¾"		
3	~~28¾~~ 36¼"		
4	~~36¼~~ 50¾"		
5	~~50¾~~ 65¼"		
6	~~65¼~~ 79¾"		

*Inches from wall plus coupling length

CARNOT

CONTINUOUS EMISSIONS MEASUREMENTS

Client PGT/Station 6 Unit A
Date 12/10/90
Test Location Stack
Ambient Temperature, DB/WB
Operator KCH/MS

Test No(s) O_2/CO_2 Traverse
Barometric Pressure 27.66 in Hg
Duct Static Pressure
Fuel Nat. GAS

Test No.	Sample Time	Point	Dry, Uncorrected O_2	CO_2	CO	NOx	NO	NO_2	SO_2	Corrected to 15 % O_2, Dry CO	NOx	SO_2	WBKQF
	858	Pre-test calibration	0.0 / 12.5	0.0 / 15.0	0.0 / 56	0.0 / 145							
	902 904	A-6	15.45	3.00	4.5	165							
	904 906	A-5	15.45	3.00	2	162.5							
	906 908	A-4	15.45	3.00	1	161.5					175.9		
	908 910	A-3	15.5	3.0	1	161.5							
	910 912	A-2	15.50	3.00	1	160.0							
	912 914	A-1	AIR In-Leakage										
		CAL AS FOUND	0.0 / 12.6	0.0 / 15.0									
	917 919	B-6	15.45	3.00	1	163.8					177.3		
	919 921	B-5	15.45	3.00	1	163.8							
	921 923	B4	15.45	3.00	1	163.8							
	923 925	B3	15.45	3.00	<1	163.8							
	927 929	B2	15.45	3.0	<1	162.5							
		B-1	AIR In-Leakage										
Span Gas Concentration			12.5	15.0	35.8	146.4							

Comments:

CARNOT

CONTINUOUS EMISSIONS MEASUREMENTS

Client PGT/Station 6 Unit A
Date 12/10/90
Test Location Stack
Ambient Temperature, DB/WB 43.5/42.5
Operator KCH/MS @09:42

Test No(s) O_2/CO_2 Traverse (Cont'd)
Barometric Pressure
Duct Static Pressure
Fuel Nat. Gas

Test No.	Sample Time	Point	Dry, Uncorrected O_2	CO_2	CO	NOx	NO	NO_2	SO_2	Corrected to ___% ___, Dry CO	NOx	SO_2
		CAL AS FOUND	0.0 / 12.6	0.0 / 15.0		/ 146						
	932 934	C-6	15.33	3.00	1	162.5						
	934 936	C-5	15.33	3.00	1	162.5						
	936 938	C-4	15.33	3.00	1	162.5						
	938 940	C-3	15.38	3.00	1	162.5						
	940 942	C-2	15.38	3.00	1	161.3						
	942 944	C-1	15.5	3.00	1	160.0						
	945	CAL AS FOUND	/ 12.55	/ 14.95								
	947 949	D-6	15.33	3.03	1	162.5						
	949 951	D-5	15.33	3.03	1	162.5					172.1	
	951 953	D-4	15.33	3.03	1	162.5						
	953 955	D-3	15.33	3.03	1	161.3						
	955 957	D-2	15.33	3.00	1	161.3						
		D-1										
Span Gas Concentration												

Comments:

CARNOT

CONTINUOUS EMISSIONS MEASUREMENTS

Client PGT/Station 6 Unit A

Date

Test Location

Ambient Temperature, DB/WB

Operator

Test No(s) O_2/CO_2 Traverse

Barometric Pressure

Duct Static Pressure

Fuel

Test No.	Sample Time	Point	Dry, Uncorrected							Corrected to 15% O_2, Dry		
			O_2	CO_2	CO	NOx	NO	NO_2	SO_2	CO	NOx	SO_2
		CAL AS FOUND	12.5	15.0								
	1004 1006	E-6	15.38	3.00	1	160.5					171.6	
	1006 1008	E-5	15.38	3.00	1	160.5						
	1008 1010	E-4	15.38	3.00	1	160.0						
	1010 1012	E-3	15.38	3.00	1	160.0						
	1012 1014	E-2	15.38	3.00	1	160.0						
	1014 1016	E-1	15.43	3.00	1	157.5						
		CAL AS FOUND	0.0 / 12.5	0.0 / 14.95	1 / 565	0.0 / 195						
Span Gas Concentration												

Comments:

CARNOT

CONTINUOUS EMISSIONS MEASUREMENTS

Client PGT / Station 6 unit A
Date 12/10/90
Test Location Stack
Ambient Temperature, DB/WB (See below)
Operator KCH/

Test No(s) 5-6A
Barometric Pressure 27.66
Duct Static Pressure
Fuel

Test No.	Sample Time	Point	Dry, Uncorrected O_2	CO_2	CO	NOx	NO	NO_2	SO_2	Corrected to 15 % O_2, Dry CO	NOx	SO_2	WB/DB
	1059 1104	Pre test Analyzer CAL	0.0 / 12.5	0.0 / 15.0	0.0 / 56.5	0.0 / 146.4							
	1105 1115	D-4	15.31	3.00	1	161.3					170.3		
	1115 1125		15.30	3.00	1	162.8					171.5		
	1125 1135		15.30	3.06	1	162.3					170.0		43.5/45
	1135 1145		15.28	3.00	1	161.3					169.3		
	1145 1155		15.25	3.00	1	162.3					169.5		44/46
	1155 1205		15.25	3.00	1	161.8					169.0		
	1206	Post test CAL As Found	0.0 / 12.38	0.0 / 15.0	0.0 / 56.5	0.0 / 145.0							
		% Drift (% of SPAN)	0 / -.96	0 / 0	0 / 0	0 / -.96							
		Average:	15.28	3.00	1	162.0					170.1		
Span Gas Concentration			12.5	15.0	56.8	146.4							

Comments: Probe place @ port which measured lowest O_2 and highest CO_2. No ~~variation~~ point-to-point variation was measured. Point 4 was selected as representative

CARNOT

CONTINUOUS EMISSIONS MEASUREMENTS

Client PGT/Station 6 Unit A

Date 12/10/90

Test Location Stack

Ambient Temperature, DB/WB (See below)

Operator

Test No(s) 6-6A

Barometric Pressure 27.66

Duct Static Pressure

Fuel

Test No.	Sample Time	Point	Dry, Uncorrected O_2	CO_2	CO	NOx	NO	NO_2	SO_2	Corrected to 15 % O_2, Dry CO	NOx	SO_2	WB/DB
	1213	Pre-test CALIBRATION	0 / 12.5	0 / 15	0 / 56.5	0 / 146.4							
	1220 1230	D-4	15.30	3.00	1	163.8					172.6		
	1230 1240		15.30	3.00	1	162.3					171.0		43.5/44.0
	1240 1250		15.30	3.00	1	161.3					170.0		
	1250 1300		15.30	3.00	1	160.8					169.4		
	1300 1310		15.30	3.00	1	160.8					169.4		
	1310 1320		15.30	3.00	1	160.3					168.9		
		Post-test cal As Found	0.0 / 12.5	0.0 / 15.0	0.0 / 56.5	0.5 / 145							
		Drift % of Span	0 / 0	0 / 0	0 / 0	.34% / -.96%							
		Average	15.30	3.00	1	161.6					170.3		
Span Gas Concentration			12.5	15.0	55.8	146.4							

Comments:

CARNOT

CONTINUOUS EMISSIONS MEASUREMENTS

Client PGT/STATION 6 UNIT A

Date 12/10/90

Test Location STACK

Ambient Temperature, DB/WB 43/44

Operator

Test No(s) 7-6A

Barometric Pressure 27.63

Duct Static Pressure

Fuel N. GAS

Test No.	Sample Time	Point	Dry, Uncorrected O_2	CO_2	CO	NOx	NO	NO_2	SO_2	Corrected to 15 % O_2, Dry CO	NOx	SO_2	WB/DB
		PRE TEST CAL	0.0 / 12.5	0.0 / 15.0	0.0 / 56.5	0.0 / 146.4							43/44
	1335 1345	D-4	15.33	3.00	1	162.5					172.1		
	1345 1355		15.33	3.00	1	162.5					172.1		43/43
	1355 1405		15.33	3.00	1	162.5					172.1		
	1405 1415		15.33	3.00	1	163.0					172.7		
	1415 1425		15.33	3.00	1	163.8					173.5		
	1425 1435		15.33	3.00	1	163.0					172.7		
	1436	POST TEST CAL AS FOUND	0.0 / 12.5	0.0 / 14.95	0.0	0.0 / 146.4							
		DRIFT % OF SPAN	0.0 / 0.0	0.0 / 0.0	0.0 / 56.5	0.0 / 0.0							
		AVERAGE	15.33	3.00	1	162.9					172.6		
Span Gas Concentration													

Comments:

APPENDIX D

UNIT OPERATING DATA

KCH
12/9

PGT - Station 6 A
December 1990

Test No. 5-6A	#1						
Date	12/10						
Time	11 am	11:15	11:30	11:45	12:00		
Data By:	CTA	CTA	CTA	CTA	CTA		
Fuel Flow Rate MSCF / SCF x 1000	997755 / 1090	997781 / 1097	997809 / 1093	997836 / 1092	997864 / 1094		
Exhaust Temp.	948°f	947°	946°7	946°f	947°		
T-5	1375°f	1375°	1375°	1375°	1375°		
Gas Producer Speed (NGP)	102% / 11061 rpm	102% / 11080	102% / 11080	102% / 11086	102% / 11074		
Gas Producer Comp Discharge (PCP)	202 PSI	203 PSI	203 PSI	203 PSI	202 PSI		
Inlet pressure	14.0/14.1 PSIA	14.1 PSIA	14.1 PSIA	14.1 PSIA	14.1 PSIA		
Rel Humidity	86%	86%	88%	86%	81/82%		
T-1 (ambient)	46°f	46°f	45°	46°f	45°		
Barometric	940 millibars	940	940	940	940		
	27.75/10" Hg						
Ambient	44°						

KCH
12/9

PGT - Station 6 A
December 1990

Test No.		O_2 TRAVERSE					
Date		12/10					
Time		9:15	9:42				
Data By:		CTA	CTA				
Fuel Flow Rate	x100	1102	1093				
	msef	997561	997611				
Exhaust Temp.		950°f	949°				
T-5		1375°f	1375				
Gas Producer Speed (NGP)		102%	102				
		11118 RPM	11099				
Gas Producer Comp Discharge (PCP)		204 PSI	203 PSI				
Inlet pressure		14.2 PSIA	14.0 PSIA				

Rel Humidity	87%	85%
Ambient T°	40°f	40°
T-1	44°f	46°f
Bar -	940 millibars	940

27 (~~[illegible]~~) Hg
7.5
10

SCREEN DUMP TIME: 10 DEC 1990 11:05:03.5

ANALOG DATA

AVG	1375	°F	NGP SPEED	102	%	SUCTION PRS	660	PSI
MAX	1426	°F	NGP SPEED	11054	RPM	DISCHG PRS	738	PSI
MIN	1314	°F	NPT SPEED	76	%	DISCHG TEMP.	61	°F
+ COMP	115	°F	NPT SPEED	7210	RPM	COMP.THRST OUT	176	°F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	176	°F
TEMP	46	°F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	167	°F	GV POS.	-4.4	V	BUF.AIR DP	25	PSI
THRUST	169	°F	BV DRIVE	4	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	215	°F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
R INLET DP	1	H20	ENGINE PCD	202	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
L TANK TEMP.	165	°F	OIL PRESS.	41.9	PSI			
BE OILTEMP	146	°F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	368	PSI	AMBT PRESS	14.0	PSIA
RVO HYD PRS	975	PSI	OIL FILTER DP	18	PSI	REL HUMIDITY	86	%

SCREEN DUMP TIME: 10 DEC 1990 11:15:22.6

ANALOG DATA

AVG	1376	°F	NGP SPEED	102	%	SUCTION PRS	660	PSI
MAX	1427	°F	NGP SPEED	11080	RPM	DISCHG PRS	738	PSI
MIN	1311	°F	NPT SPEED	76	%	DISCHG TEMP.	61	°F
+ COMP	115	°F	NPT SPEED	7210	RPM	COMP.THRST OUT	177	°F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	°F
TEMP	46	°F	GV DRIVE	-2	MA	BUF.GAS FIL DP	0	PSI
THRUST	167	°F	GV POS.	-4.4	V	BUF.AIR DP	25	PSI
THRUST	169	°F	BV DRIVE	4	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	216	°F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
R INLET DP	1	H20	ENGINE PCD	203	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
L TANK TEMP.	165	°F	OIL PRESS.	41.9	PSI			
BE OILTEMP	144	°F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	368	PSI	AMBT PRESS	14.1	PSIA
RVO HYD PRS	976	PSI	OIL FILTER DP	19	PSI	REL HUMIDITY	86	%

SCREEN DUMP TIME: 10 DEC 1990 11:30:18.8

ANALOG DATA

AVG	1375	°F	NGP SPEED	102	%	SUCTION PRS	658	PSI
MAX	1426	°F	NGP SPEED	11080	RPM	DISCHG PRS	739	PSI
MIN	1309	°F	NPT SPEED	76	%	DISCHG TEMP.	61	°F
+ COMP	120	°F	NPT SPEED	7214	RPM	COMP.THRST OUT	177	°F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	°F
TEMP	45	°F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	169	°F	GV POS.	-4.4	V	BUF.AIR DP	25	PSI
THRUST	171	°F	BV DRIVE	4	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	216	°F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
R INLET DP	1	H20	ENGINE PCD	203	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
L TANK TEMP.	167	°F	OIL PRESS.	42.1	PSI			
BE OILTEMP	146	°F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	369	PSI	AMBT PRESS	14.1	PSIA
RVO HYD PRS	976	PSI	OIL FILTER DP	19	PSI	REL HUMIDITY	88	%

SCREEN DUMP TIME: 10 DEC 1990 11:45:04.7

ANALOG DATA

AVG	1376	°F	NGP SPEED	102	%	SUCTION PRS	658	PSI
MAX	1423	°F	NGP SPEED	11080	RPM	DISCHG PRS	739	PSI
MIN	1312	°F	NPT SPEED	76	%	DISCHG TEMP.	62	°F
+ COMP	122	°F	NPT SPEED	7219	RPM	COMP.THRST OUT	178	°F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	176	°F
TEMP	45	°F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	168	°F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
THRUST	171	°F	BV DRIVE	4	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	217	°F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
R INLET DP	1	H20	ENGINE PCD	203	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
L TANK TEMP.	167	°F	OIL PRESS.	42.0	PSI			
BE OILTEMP	145	°F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	369	PSI	AMBT PRESS	14.1	PSIA
RVO HYD PRS	976	PSI	OIL FILTER DP	18	PSI	REL HUMIDITY	86	%

PGT - Station 6 A
December 1990

Test No. 6-6A	#2					
Date	12/10/90					
Time	12:20	12:30	12:35	12:50	1:05	1:20
Data By:	CTA		CTA			
Fuel Flow Rate mscf / scf/hr x 1000	99790 / 1098	997920 / 1104	997927 / 1105	997955 / 1108	997983 / 1109	998011 / 1108
Exhaust Temp.	947°F	947°F	947	946°	945	945°
T-5	1375°F	1375°F	1375°F	1375°F	1375°	1376
Gas Producer Speed (NGP)	102% / 11099 rpm	102 / 11093	102 / 11093	102 / 11080	102 / 11093	102 / 11086
Gas Producer Comp Discharge (PCP)	203 PSI	202	202	203	203	203
Inlet pressure	14.1 PSIA	14.1	14.1	14.1	14.1	14.1
Barometer	940	940	940	940	939	939
Rel Humidity	83%	83%	80%	83%	86	85%
T-1 (Ambient)	45°F	45°F	46°	45°	45°	440

SCREEN DUMP TIME: 10 DEC 1990 12:20:28.0

ANALOG DATA

) AVG	1375	"F	NGP SPEED	102	%	SUCTION PRS	656	PSI
5 MAX	1426	"F	NGP SPEED	11093	RPM	DISCHG PRS	739	PSI
5 MIN	1314	"F	NPT SPEED	77	%	DISCHG TEMP.	62	"F
I + COMP	124	"F	NPT SPEED	7267	RPM	COMP.THRST OUT	178	"F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	"F
TEMP	45	"F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	167	"F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
THRUST	171	"F	BV DRIVE	4	MA	SEAL VNT PR	1	PSI
NG.2BRG DRN	218	"F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
IR INLET DP	1	H2O	ENGINE PCD	203	PSI			
IL TNK PRS	1	H2O	FUEL ACTUATOR	25	MA			
IL TANK TEMP.	167	"F	OIL PRESS.	42.0	PSI			
UBE OILTEMP	145	"F	BAT.VOLT	24.3	V	COALESCER	1	H2O
TARTR PRES	-0	PSI	GAS FUEL PRS	368	PSI	AMBT PRESS	14.0	PSIA
ERVO HYD PRS	976	PSI	OIL FILTER DP	19	PSI	REL HUMIDITY	83	%

SCREEN DUMP TIME: 10 DEC 1990 12:30:15.6

ANALOG DATA

5 AVG	1373	"F	NGP SPEED	102	%	SUCTION PRS	656	PSI
5 MAX	1427	"F	NGP SPEED	11099	RPM	DISCHG PRS	738	PSI
5 MIN	1311	"F	NPT SPEED	77	%	DISCHG TEMP.	62	"F
I + COMP	124	"F	NPT SPEED	7285	RPM	COMP.THRST OUT	179	"F
CTIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	"F
TEMP	45	"F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	167	"F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
THRUST	171	"F	BV DRIVE	4	MA	SEAL VNT PR	1	PSI
NG.2BRG DRN	218	"F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
IR INLET DP	1	H2O	ENGINE PCD	203	PSI			
IL TNK PRS	1	H2O	FUEL ACTUATOR	26	MA			
IL TANK TEMP.	167	"F	OIL PRESS.	42.1	PSI			
UBE OILTEMP	145	"F	BAT.VOLT	24.3	V	COALESCER	1	H2O
TARTR PRES	-0	PSI	GAS FUEL PRS	368	PSI	AMBT PRESS	14.1	PSIA
ERVO HYD PRS	976	PSI	OIL FILTER DP	18	PSI	REL HUMIDITY	84	%

SCREEN DUMP TIME: 10 DEC 1990 12:49:21.4

ANALOG DATA

AVG	1375	°F	NGP SPEED	102	%	SUCTION PRS	655	PSI
MAX	1427	°F	NGP SPEED	11080	RPM	DISCHG PRS	739	PSI
MIN	1317	°F	NPT SPEED	77	%	DISCHG TEMP.	62	°F
+ COMP	127	°F	NPT SPEED	7280	RPM	COMP.THRST OUT	178	°F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	°F
TEMP	45	°F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	167	°F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
THRUST	171	°F	BV DRIVE	4	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	217	°F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
R INLET.DP	1	H20	ENGINE PCD	202	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	26	MA			
L TANK TEMP.	166	°F	OIL PRESS.	42.0	PSI			
BE OILTEMP	145	°F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	368	PSI	AMBT PRESS	14.1	PSIA
RVO HYD PRS	976	PSI	OIL FILTER DP	18	PSI	REL HUMIDITY	84	%

SCREEN DUMP TIME: 10 DEC 1990 13:04:35.6

ANALOG DATA

5 AVG	1376	°F	NGP SPEED	102	%	SUCTION PRS	656	PSI
5 MAX	1427	°F	NGP SPEED	11093	RPM	DISCHG PRS	738	PSI
5 MIN	1314	°F	NPT SPEED	77	%	DISCHG TEMP.	62	°F
+ COMP	128	°F	NPT SPEED	7280	RPM	COMP.THRST OUT	179	°F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	°F
1 TEMP	45	°F	GV DRIVE	-2	MA	BUF.GAS FIL DP	2	PSI
P THRUST	167	°F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
T THRUST	171	°F	BV DRIVE	3	MA	SEAL VNT PR	1	PSI
NG.2BRG DRN	217	°F	BV POS.	4.9	V	BUF.GAS DP	24	PSI
IR INLET DP	1	H20	ENGINE PCD	203	PSI			
IL TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
IL TANK TEMP.	167	°F	OIL PRESS.	42.0	PSI			
BE OILTEMP	145	°F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	366	PSI	AMBT PRESS	14.1	PSIA
RVO HYD PRS	975	PSI	OIL FILTER DP	19	PSI	REL HUMIDITY	86	%

SCREEN DUMP TIME: 10 DEC 1990 13:19:58.4

ANALOG DATA

AVG	1375	°F	NGP SPEED	102	%	SUCTION PRS	657	PSI
MAX	1420	°F	NGP SPEED	11086	RPM	DISCHG PRS	738	PSI
MIN	1321	°F	NPT SPEED	77	%	DISCHG TEMP.	62	°F
+ COMP	128	°F	NPT SPEED	7267	RPM	COMP.THRST OUT	178	°F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	°F
TEMP	44	°F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	167	°F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
THRUST	171	°F	BV DRIVE	3	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	218	°F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
R INLET DP	1	H20	ENGINE PCD	203	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
L TANK TEMP.	167	°F	OIL PRESS.	42.1	PSI			
BE OILTEMP	145	°F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	369	PSI	AMBT PRESS	14.1	PSIA
RVO HYD PRS	973	PSI	OIL FILTER DP	19	PSI	REL HUMIDITY	86	%

KCH
12/9

PGT - Station 6 A
December 1990

Test No. T-6A 100%	# 3						
Date	12/10						
Time	13:35	13:50	14:05	14:20	14:35		
Data By:	CTA						
Fuel Flow Rate X100 scf/hr ~~MSCF~~	1105 998040	1103 998066	1104 998094	1101 998121	1097 998149		
Exhaust Temp. °F	945	945	945	945	945		
T-5 °F	1376	1375	1375	1375	1375		
Gas Producer Speed (NGP)	102 11106 rpm	102 11099	102 11099	102 11106	102 11093		
Gas Producer Comp Discharge (PCD) PSI	204 PSI	203	203	204	203		
Inlet pressure PSIA	14.1 PSIA	14.1	14.1	14.1	14.1		

Barometer	938.5	939	939	938.5	938.5
Rel. Humidity	91%	90/91%	91% ~~90%-92~~	92%	91%
T-1 (Ambient)	43°F	43°F	43°F	43°F	44°

Printer Problems unable to get 13:35 Printed

SCREEN DUMP TIME: 10 DEC 1990 13:40:19.8

ANALOG DATA

AVG	1376	°F	NGP SPEED	102	%	SUCTION PRS	657	PSI
MAX	1421	°F	NGP SPEED	11099	RPM	DISCHG PRS	737	PSI
MIN	1314	°F	NPT SPEED	77	%	DISCHG TEMP.	62	°F
+ COMP	129	°F	NPT SPEED	7276	RPM	COMP.THRST OUT	178	°F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	°F
TEMP	43	°F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	167	°F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
THRUST	171	°F	BV DRIVE	3	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	218	°F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
R INLET DP	1	H20	ENGINE PCD	203	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
L TANK TEMP.	166	°F	OIL PRESS.	42.0	PSI			
BE OILTEMP	144	°F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	369	PSI	AMBT PRESS	14.1	PSIA
RVO HYD PRS	976	PSI	OIL FILTER DP	19	PSI	REL HUMIDITY	91	%

SCREEN DUMP TIME: 10 DEC 1990 13:50:39.0

ANALOG DATA

AVG	1376	°F	NGP SPEED	102	%	SUCTION PRS	657	PSI
MAX	1420	°F	NGP SPEED	11099	RPM	DISCHG PRS	738	PSI
MIN	1318	°F	NPT SPEED	77	%	DISCHG TEMP.	62	°F
+ COMP	128	°F	NPT SPEED	7258	RPM	COMP.THRST OUT	179	°F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	°F
TEMP	43	°F	GV DRIVE	-2	MA	BUF.GAS FIL DP	0	PSI
THRUST	167	°F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
THRUST	171	°F	BV DRIVE	3	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	218	°F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
R INLET DP	1	H20	ENGINE PCD	204	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
L TANK TEMP.	167	°F	OIL PRESS.	42.0	PSI			
BE OILTEMP	145	°F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	370	PSI	AMBT PRESS	14.1	PSIA
RVO HYD PRS	976	PSI	OIL FILTER DP	19	PSI	REL HUMIDITY	91	%

SCREEN DUMP TIME: 10 DEC 1990 14:04:29.9

ANALOG DATA

AVG	1375	"F	NGP SPEED	102	%	SUCTION PRS	657	PSI
MAX	1421	"F	NGP SPEED	11099	RPM	DISCHG PRS	739	PSI
MIN	1317	"F	NPT SPEED	77	%	DISCHG TEMP.	62	"F
+ COMP	129	"F	NPT SPEED	7258	RPM	COMP.THRST OUT	178	"F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	"F
TEMP	43	"F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	167	"F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
THRUST	171	"F	BV DRIVE	3	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	218	"F	BV POS.	5.0	V	BUF.GAS DP	23	PSI
R INLET DP	1	H20	ENGINE PCD	204	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
L TANK TEMP.	167	"F	OIL PRESS.	42.1	PSI			
BE OILTEMP	145	"F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	369	PSI	AMBT PRESS	14.1	PSIA
RVO HYD PRS	976	PSI	OIL FILTER DP	19	PSI	REL HUMIDITY	91	%

SCREEN DUMP TIME: 10 DEC 1990 14:19:25.5

ANALOG DATA

AVG	1376	"F	NGP SPEED	102	%	SUCTION PRS	657	PSI
MAX	1421	"F	NGP SPEED	11106	RPM	DISCHG PRS	739	PSI
MIN	1317	"F	NPT SPEED	77	%	DISCHG TEMP.	62	"F
+ COMP	129	"F	NPT SPEED	7249	RPM	COMP.THRST OUT	178	"F
TIVE TC	17		NPT EXT.SET	99	%	COMP.THRST IN	177	"F
TEMP	43	"F	GV DRIVE	-2	MA	BUF.GAS FIL DP	1	PSI
THRUST	167	"F	GV POS.	-4.5	V	BUF.AIR DP	25	PSI
THRUST	171	"F	BV DRIVE	4	MA	SEAL VNT PR	1	PSI
G.2BRG DRN	218	"F	BV POS.	4.9	V	BUF.GAS DP	23	PSI
R INLET DP	1	H20	ENGINE PCD	204	PSI			
L TNK PRS	1	H20	FUEL ACTUATOR	25	MA			
L TANK TEMP.	166	"F	OIL PRESS.	42.0	PSI			
BE OILTEMP	145	"F	BAT.VOLT	24.3	V	COALESCER	1	H20
ARTR PRES	-0	PSI	GAS FUEL PRS	369	PSI	AMBT PRESS	14.0	PSIA
RVO HYD PRS	976	PSI	OIL FILTER DP	18	PSI	REL HUMIDITY	91	%

APPENDIX E

EMISSIONS CALCULATIONS

GAS FUEL "F" FACTOR CALCULATIONS

Source - PGT Station 6
BY - KCH
DATE - 01/15/91
TIME - 11:56
Reference Temp, °F 60

SPECIES	VOL.%	lb./lb-mol.(Fuel) C	H	O	N	S
CH4	97.3000	11.676	3.892	0.000	0.000	0.000
C2H6	2.0000	0.480	0.120	0.000	0.000	0.000
C3H8	0.2000	0.072	0.016	0.000	0.000	0.000
C4H10 - I	0.0000	0.000	0.000	0.000	0.000	0.000
C4H10 - N	0.0000	0.000	0.000	0.000	0.000	0.000
C5H12 - I	0.0000	0.000	0.000	0.000	0.000	0.000
C5H12 - N	0.0000	0.000	0.000	0.000	0.000	0.000
C6H6	0.0000	0.000	0.000	0.000	0.000	0.000
CO2	0.4000	0.048	0.000	0.128	0.000	0.000
N2	0.0000	0.000	0.000	0.000	0.000	0.000
H2S	1.00E-05	0.000	0.000	0.000	0.000	0.000
	99.90					
Total		12.276	4.028	0.128	0.000	0.00000
WT.%		74.708	24.513	0.779	0.000	0.00002

GAS MW = 16.432 lb/lb-mole
HHV = 1025.00 Btu/SCF
23672.55 Btu/lb
DENSITY = 0.0433 lb/SCF

F - FACTOR: (O2 based)
@ 68 °F= 8,583 DSCF/MMBtu @ 0% O2
@ 60 °F= 8,453 DSCF/MMBtu @ 0% O2

F - FACTOR: (CO2 based)
@ 68 °F= 1013.04 DSCF/MMBtu
@ 60 °F= 997.69 DSCF/MMBtu

O2 BASED

TEST NO	FUEL FLOW (SCFH)	EXHAUST O2 (% dry)	EXHAUST FLOW (DSCFM)	SO2 lb/hr	SO2 ppm	SO2 ppm @15%O2
5-6A	109300	15.28	58,694	0.001	0.000	0.000
6-6A	110500	15.30	59,550	0.001	0.000	0.000
7-6A	110240	15.33	59,730	0.001	0.000	0.000

CO2 BASED

TEST NO	FUEL FLOW (SCFH)	EXHAUST O2 (% dry)	EXHAUST FLOW (DSCFM)	SO2 lb/hr	SO2 ppm	SO2 ppm @15%O2
5-6A	109300	3.00	62,097	0.001	0.000	0.000
6-6A	110500	3.00	62,778	0.001	0.000	0.000
7-6A	110240	3.00	62,631	0.001	0.000	0.000

EMISSION CALCULATIONS

1. Sample Volume and Isokinetics

a. Sample gas volume, dscf

$$V_{m\ std} = 0.03342 V_m [P_{bar} + (H/13.6)](T_{ref}/T_m)(Y)$$

b. Water vapor volume, scf

$$V_{w\ std} = 0.0472\ V_{lc}\ (T_{ref}/528°R)$$

c. Moisture content, nondimensional

$$Bwo = V_{w\ std}/(V_{m\ std} + V_{w\ std})$$

d. Stack gas molecular weight, lb/lb mole

$$MW_{dry} = 0.44(\%\ CO_2) + 0.32(\%\ O_2) + 0.28(\%\ N_2)$$

$$MW_{wet} = MW_{dry}\ (1 - B_{wo}) + 18\ (B_{wo})$$

e. Absolute stack pressure, iwg

$$Ps = P_{bar} + P_{sg}/13.6$$

f. Stack velocity, ft/sec

$$V_s = 2.90\ C_p \sqrt{\Delta PTs}\ \sqrt{\frac{29.92}{Ps} x \frac{28.95}{MW_{wet}}}$$

g. Actual stack gas flow rate, wacfm

$$Q = (V_s)(A_s)(60)$$

h. Standard stack gas flow rate, dscfm

$$Q_{sd} = Q\ (1 - Bwo)(T_{ref}/Ts)(Ps/29.92)$$

i. Percent isokinetic

$$I = \frac{17.32 \times T_s\ (V_{m\ std})}{(1-Bwo)\theta \times V_s \times Ps \times Dn^2} \times \frac{528\ °R}{T_{ref}}$$

2. Particulate Emissions

a. Grain loading, gr/dscf

$$C = 0.01543\ (M_n/V_{m\ std})$$

b. Grain loading at 12% CO_2, gr/dscf

$$C_{12\%\ CO_2} = C\ (12/\%\ CO_2)$$

c. Mass emissions, lb/hr

$$M = C \times Qsd \times (60 \text{ min/hr})/(7000 \text{ gr/lb})$$

3. Gaseous Emissions, lb/hr

$$M = ppm \times 10^{-6} \frac{MW_i \text{ lb/lb mole}}{SV} \times Qsd \times 60 \text{ min/hr}$$

where SV = specific molar volume of an ideal gas:

385.3 ft^3/lb mole for T_{ref} = 528 °R
379.5 ft^3/lb mole for T_{ref} = 520 °R

4. Emissions Rates, lb/10^6 Btu

a. Fuel factor at 68 °F, dscf/10^6 Btu at 0% O_2

$$F_{68} = \frac{10^6[3.64(\%H) + 1.53(\%C) + 0.14(\%N) + 0.57(\%S) - 0.46(\%O_2, \text{fuel})]}{HHV, \text{ Btu/lb}}$$

b. Fuel factor at 60 °F

$$F_{60} = F_{68} \, (520 \text{ °R}/528 \text{ °R})$$

c. Gaseous emission factor

$$\text{lb}/10^6 \text{ Btu}_i = ppm_i \times 10^{-6} \times \frac{MW_i \text{ lb}}{\text{lb mole}} \times \frac{1}{SV} \times F \times \frac{20.9}{20.9-\%O_2}$$

d. Particulate emission factor

$$\text{lb}/10^6 \text{ Btu} = C \times \frac{1 \text{ lb}}{7000 \text{ gr}} \times F \times \frac{20.9}{20.9-\%O_2}$$

These calculations are routinely performed on Carnot's computer.

Nomenclature:

A_s = stack area, ft^2
Bwo = flue gas moisture content
$C_{12\% CO_2}$ = particulate grain loading, gr/dscf corrected to 12% CO_2
C = particulate grain loading, gr/dscf
C_p = pitot calibration factor, dimensionless
Dn = nozzle diameter, in.
F = fuel F factor, dscf/10^6 Btu at 0% O_2
H = orifice pressure differential, iwg
I = % isokinetics
M_n = mass of collected particulate, mg
M_i = mass emissions of species i, lb/hr
MW = molecular weight of flue gas
MW_i = molecular weight of species i:

NOx: 46
CO: 28
SO_2: 64
HC: 16

θ = sample time, min.
ΔP = average velocity head, iwg $= \left(\overline{\sqrt{\Delta P}}\right)^2$
P_{bar} = barometric pressure, in.Hg
Ps = stack absolute pressure, in.Hg.
Psg = stack static pressure, iwg
Q = wet stack gas flow rate at actual conditions, wacfm
Qsd = dry stack gas flow rate at standard conditions, dscfm
SV = specific molar volume of an ideal gas at std conditions, ft^3/lb mole
Tm = meter temperature, °R
T_{ref} = reference temperature, °R
Ts = stack temperature, °R
V_s = stack velocity, ft/sec
V_{lc} = volume of liquid collected in impingers, ml
Vm = dry meter volume uncorrected, dcf
$V_{m\ std}$ = dry meter volume at standard conditions, dscf
$V_{w\ std}$ = volume of water vapor at standard conditons, scf
Y = meter calibration coefficient

CARNOT

SUBJECT Calculation of ISO Factors JOB NO.

SHEET NO. 1 of 2

COMPUTED BY K. Hopkins DATE CHECKED BY DATE

$$ISO = \left(\frac{29.92}{B.P}\right)^{1/2} \left(\frac{288°K}{T_{amb}}\right)^{1.53} e^{19(H - 0.00633)}$$

B.P. : Barometric pressure, in Hg

Tamb : Ambient Temperature, K (same as dry bulb temperature)

H : humidity, lb H_2O/lb dry air

Example :

Test No. 5-6A

T wet bulb = ~~46°F~~ 43.8°F

T dry bulb = ~~48°F~~ 45.5°F = 280.5 K

B.P = 27.66 in Hg

From psychrometric chart (see attached)

H = 0.0057 lb H_2O/lb air

ISO = 1.0700

137723

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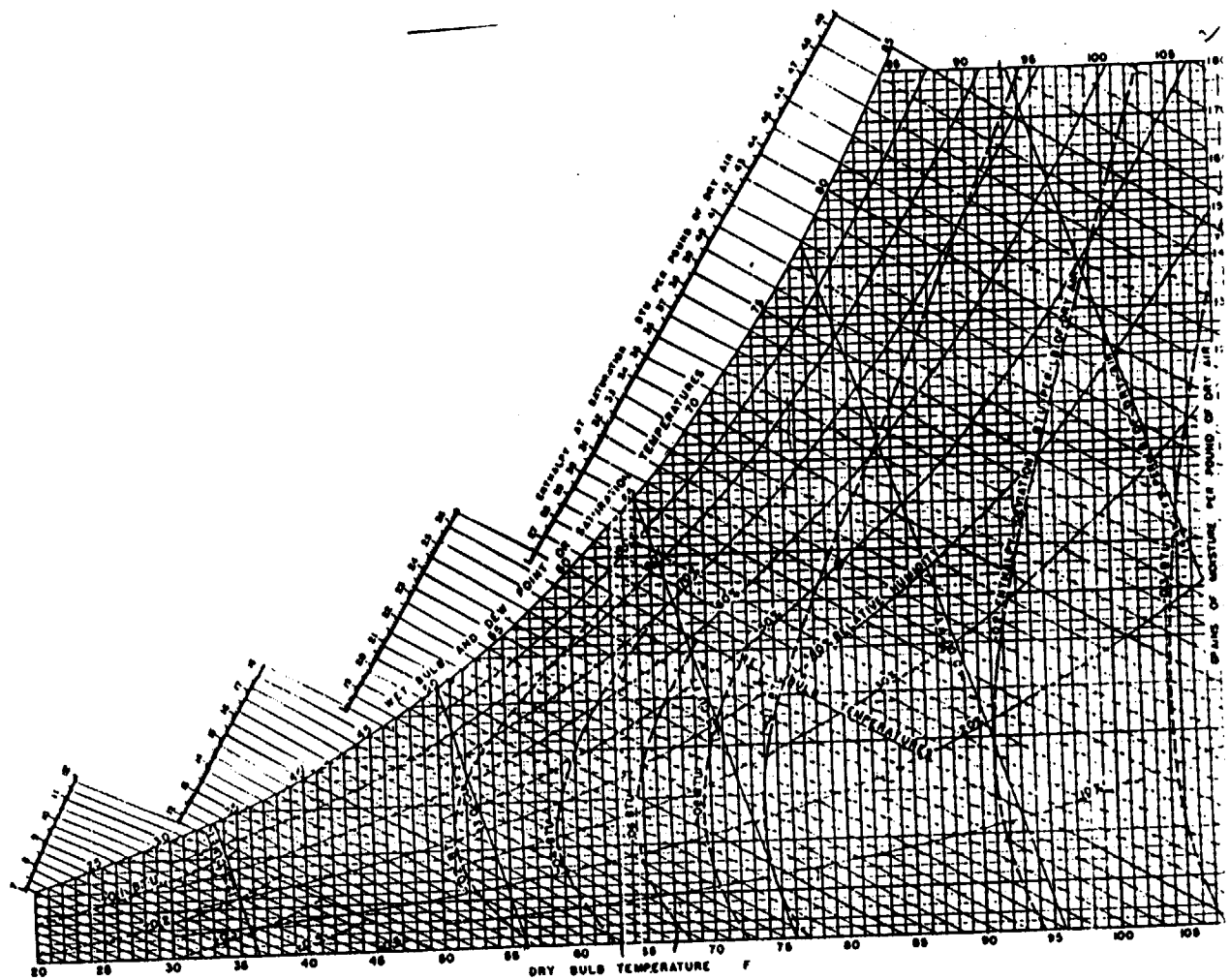

FIG. A-1 *Psychometric chart, normal temperatures, English units, $p = 1$ atm. (Carrier Corporation.)*

CARNOT

SUBJECT Calculation of EPA "F- Factor" and Exhaust Flow, and NO_x mass emissions

JOB NO. 82100

SHEET NO. 1 of 3

COMPUTED BY K. Hopkins DATE 1/4/91 CHECKED BY _____ DATE _____

GIVEN: 1. Natural Gas Fuel Analysis:

Species	CH_4	C_2H_6	C_3H_8	CO_2	H_2S
Vol%	97.3	2.0	0.2	0.4	1×10^{-5}

HHV = 1025 Btu/SCF

2. Fuel flow for test 5-6A

Q_f = 109,300 scfh

3. Exhaust O_2 = 15.28%

FIND: 1. "F-Factor" @ 60°F

2. Exhaust Flowrate, @ dscfm

Step 1. Convert from Volume % to Atom Weight %

	%VOL	C	H	O	S
CH_4	97.3	11.676	3.892	0.00	0.00
C_2H_6	2.0	0.480	0.120	0.00	0.00
C_3H_8	0.2	0.072	0.016	0.00	0.00
CO_2	0.4	0.048	0.00	0.128	0.00
H_2S	1×10^{-5}	0.00	0.00	0.00	0.00
Σ		12.276 +	4.028 +	0.128 +	0.00 = 16.432 lb/lb-mole
Wt%:		74.708	~~25.513~~ 24.513	0.779	0.00

139696

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CARNOT

SUBJECT _____ JOB NO. _____

SHEET NO. 2 of 3

COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

Step. 2. Calculate EPA "F-Factor"

From 40 CFR pt 60, App. A, Meth 19, Eq 19-13

$$F_{68} = \frac{10^{+6}\left\{(3.64)(\%H) + (1.53)(\%C) + (0.14)(\%N) + (0.57)(\%S) - (0.46)(\%O_2\ \text{fuel})\right\}}{HHV,\ Btu/lb}$$

Specific Molar Volume of an ideal gas @ 60°F

$$SV = 379.5\ \frac{ft^3}{lb\ mole}$$

$$HHV,\ Btu/lb = \frac{\left(1025\ \frac{Btu}{ft^3}\right)\left(379.5\ \frac{ft^3}{lb\cdot mole}\right)}{16.432\ \frac{lb}{lb\cdot mole}} = 23{,}672.55\ \frac{Btu}{lb}$$

$$F_{68} = \frac{10^{+6}\left\{(3.64)(24.513) + (1.53)(74.708) + (0.14)(0.6) + (0.57)(0.0) - (0.46)(20.9)\right\}}{23{,}672.55}$$

F_{68} = 8582.6 dscf/MMBtu @ 0% O_2

$$F_{60} = (8582.6)\left(\frac{526}{528}\right) = \underline{\underline{8452.6\ dscf/MMBtu\ @\ 0\%\ O_2}}$$

139696

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SUBJECT _____ JOB NO. _____

SHEET NO. 3 of 3

COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

Step 3 Compute Exhaust flow

$$Q_{exhaust} = (F_{60})(HHV)(Q_f)(10^{-6})(1/60)\left(\frac{20.9}{20.9 - \%O_2}\right)$$

$$= (8452.6)(1025)(109{,}300)(10^{-6})(1/60)\left(\frac{20.9}{20.9 - 15.20\%}\right)$$

$$\underline{\underline{Q_{exhaust} = 58{,}694 \text{ dscfm}}}$$

Step 4 Compute NOx in lb/hr

$$\dot{m}_{NO_x} = (NO_x, \text{ppm dry}) \times 10^{-6}\left(\frac{46 \text{ lb/lb-mole}}{379.5 \text{ ft}^3/\text{lb-mole}}\right) \times Q_{exhaust} \times 60$$

$$\dot{m}_{NO_x} = (162.0)(10^{-6})\left(\frac{46}{379.5}\right)(58{,}694)(60)$$

$$\underline{\underline{\dot{m}_{NO_x} = 69.15 \text{ lb/hr}}} \Rightarrow \text{test No. } 5\text{-}6A$$

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SUBJECT Calculation of Exhaust Flow Based on CO_2 based F-Factor JOB NO. _____

SHEET NO. 1 of 1

COMPUTED BY K. Hopkins DATE _____ CHECKED BY _____ DATE _____

CO_2 based F-Factor

$$F_{68} = 10^6 (\%C)(0.321) / HHV$$

$$= 10^6 (74.708)(0.321) / 23{,}672.55$$

$$= 1{,}013.04 \ dscf / 10^6 \ Btu$$

$$F_{60} = \left(\frac{520}{528}\right) F_{68} = 997.69 \ dscf / 10^6 \ Btu$$

$$Q_{exhaust} = (F_{60})(HHV)(Q_f)(10^{-6})(1/60)(100/\%CO_2)$$

Test 5-6A

$$Q_{exhaust} = (997.69)(1025)(109{,}300)(10^{-6})(1/60)\left(\frac{100}{3.00}\right)$$

$$= \underline{62{,}097 \ dscfm}$$

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CARNOT

SUBJECT Calculation of Exhaust SO_2 Concentration JOB NO. 82100

SHEET NO. 1 of 2

COMPUTED BY K. Hopkins DATE _____ CHECKED BY _____ DATE _____

Given:
1. "F-Factor" @ 60°F
2. HHV, Btu/scf
3. Exhaust O_2
4. Fuel Flow, scfh
5. wt% of Sulfur in Natural Gas

FIND: Exhaust Concentration of SO_2

Assume: All sulfur in reactants is found as SO_2 in products

"F-Factor" = 8,453 DSCF/MMBtu @ 0% O_2

Q_f = 109,300 scfh

HHV = 1025 Btu/scf

O_2 = 15.28 %

wt% S = 2.0×10^{-5} %

MW_{SO_2} = 64 lb/lb-mole

$$Q_{exhaust} = (F_{60})(HHV)(Q_f)(10^{-6})(1/60)\left(\frac{20.9}{20.9 - \%O_2}\right)$$

$$\dot{m}_{SO_2} = (Q_f)(\rho_f)\frac{wt\%S}{100}$$

$$ppm\ SO_2 = (\dot{m}_{SO_2})(10^6)(379.5)/(64\ Q_{exhaust}(60))$$

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SUBJECT _____ JOB NO. _____

SHEET NO. 2 of 2

COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

$$ppm\,SO_2 = \frac{(Q_f)(\rho_f)\left(\frac{wt\%S}{100}\right)(10^6)(379.5)}{(64)(F_{60})(HHV)(Q_f)(10^{-6})(1/60)\left(\frac{20.9}{20.9-O_2}\right)60}$$

$$ppm\,SO_2 = \frac{(2.88\times10^9)(\rho_f)(wt\%S)(20.9-\%O_2)}{(F_{60})\,(HHV)}$$

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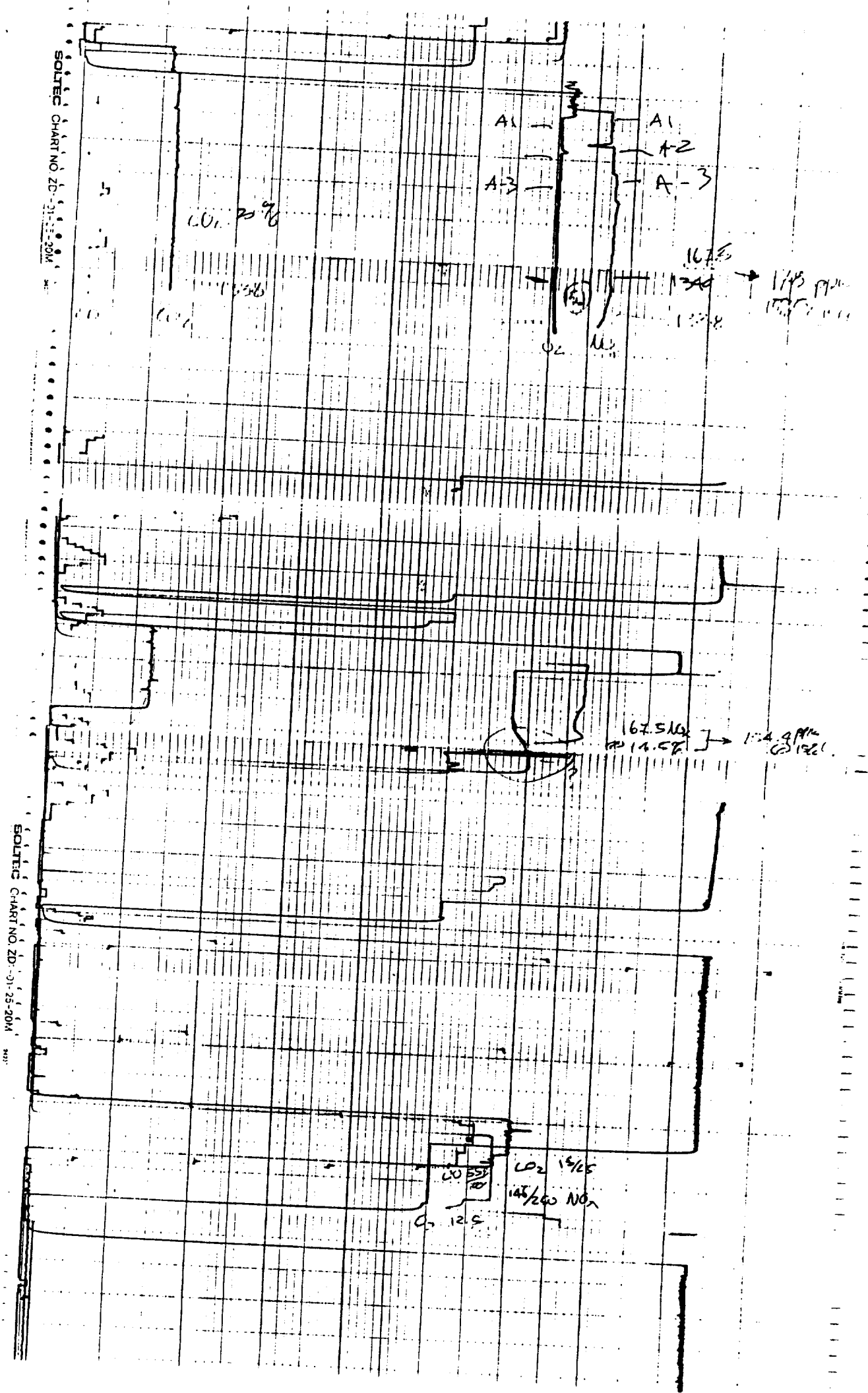
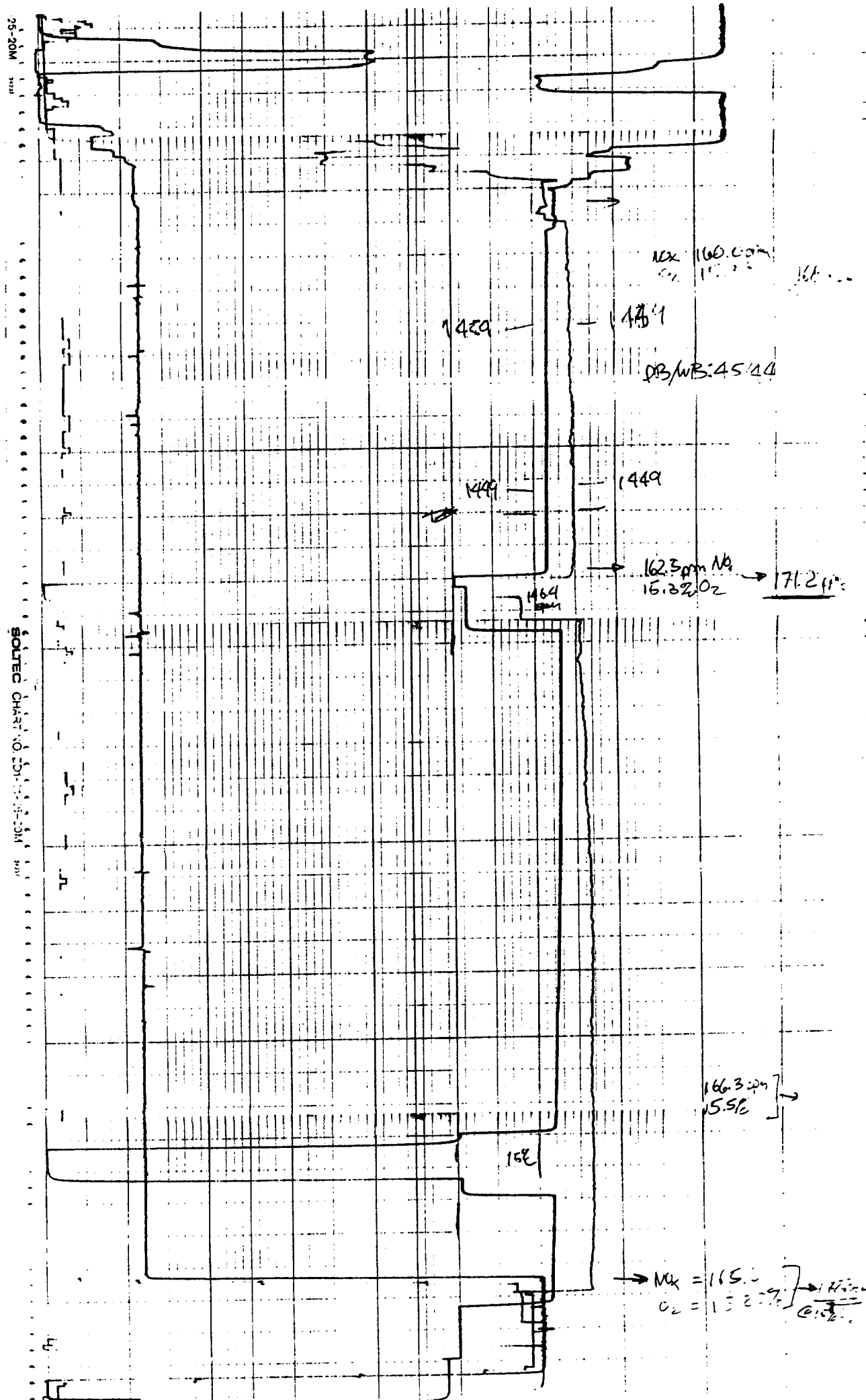
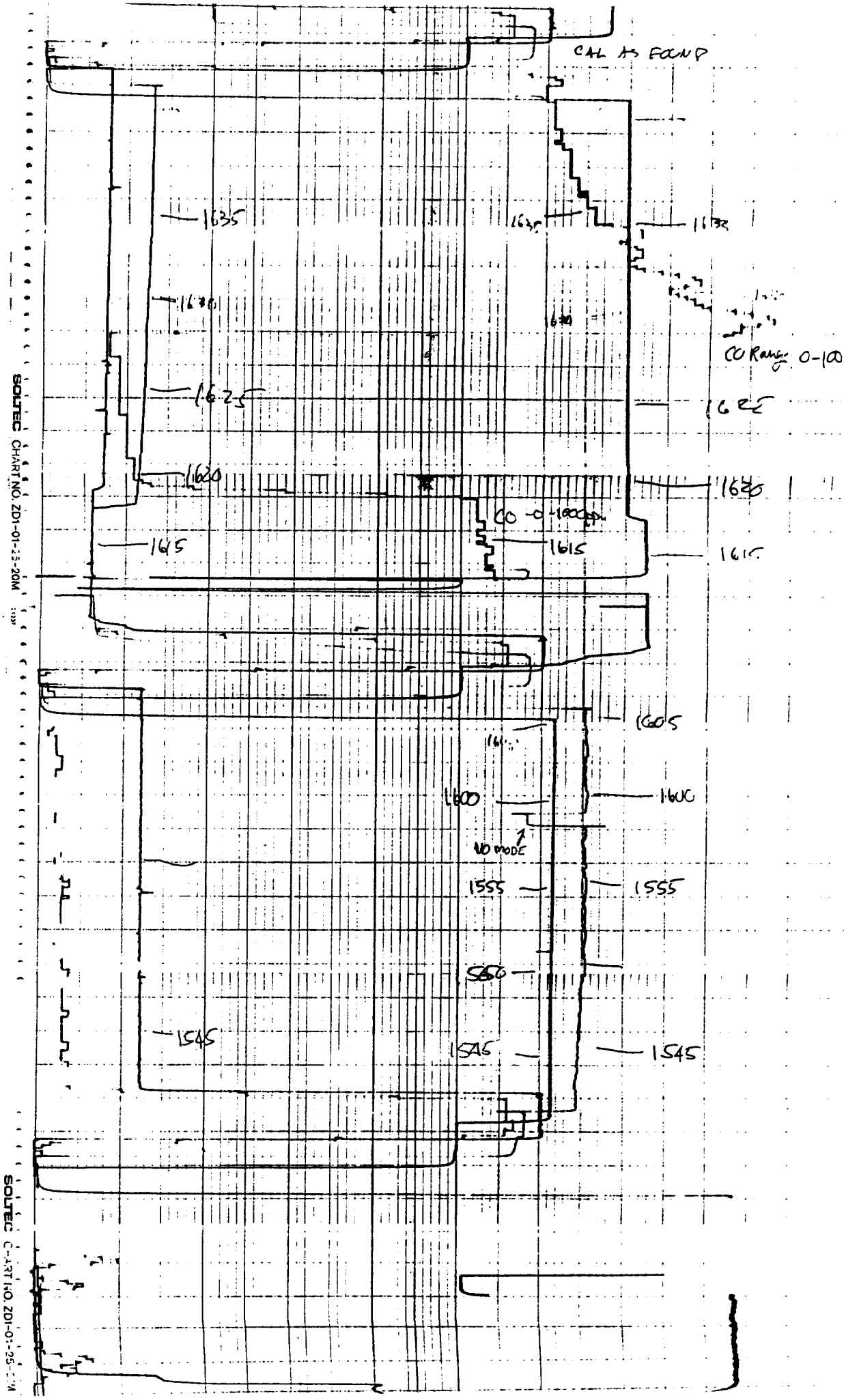
APPENDIX F

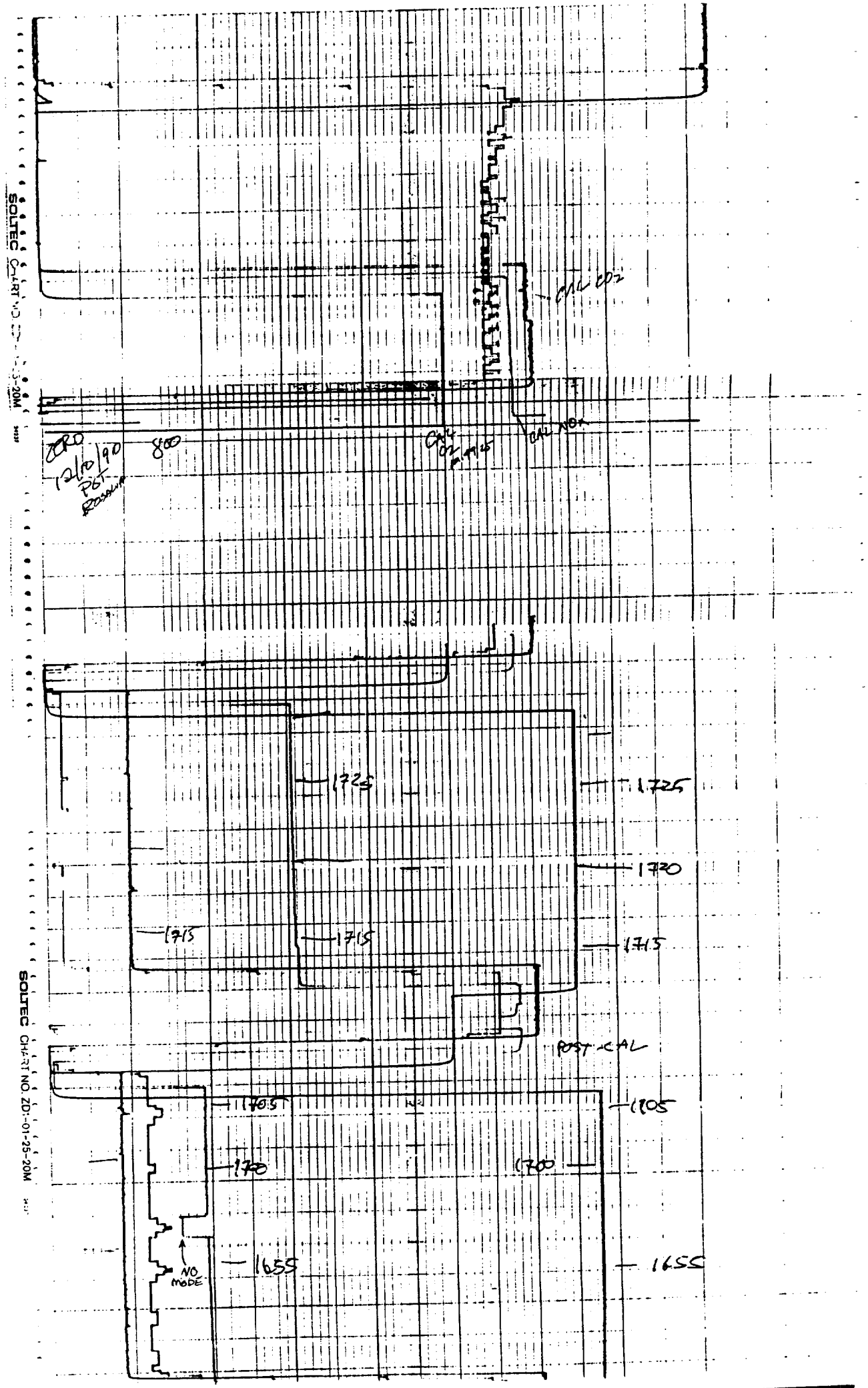
STRIP CHARTS


SOLTEC CHART NO. ZD-01-25-20M
A1
A1
A-2
A-3
A-3
CO2 20%
167.5
134.4
O2
NO2
167.5 NO2
@ 14.5%
CO2 15/25
145/260 NO2
O2 12.5
SOLTEC CHART NO. ZD-01-25-20M



25-20M
SOLTEC CHART NO. 201-25-20M
NOx 160.0 ppm
1459
1449
DB/WB: 45/44
1449
1449
162.3 ppm NOx
15.3% O2
171.2
1464
166.3 ppm
15.5%
15%
NOx = 165.
O2 = 1


CAL AS FOUND
1635
1630
1625
1620
1615
1605
1600
1555
1550
1545
CO Range 0-100
CO 0-1000ppm
NO MODE
SOLTEC CHART NO. ZD1-01-25-20M
SOLTEC CHART NO. ZD1-01-25-20M


SOLTEC CHART NO. ZD1-01-25-20M
CAL CO2
CAL NOx
ZERO
12/10/90
PST
800
1725
1720
1715
POST-CAL
1705
1700
1655
NO MODE

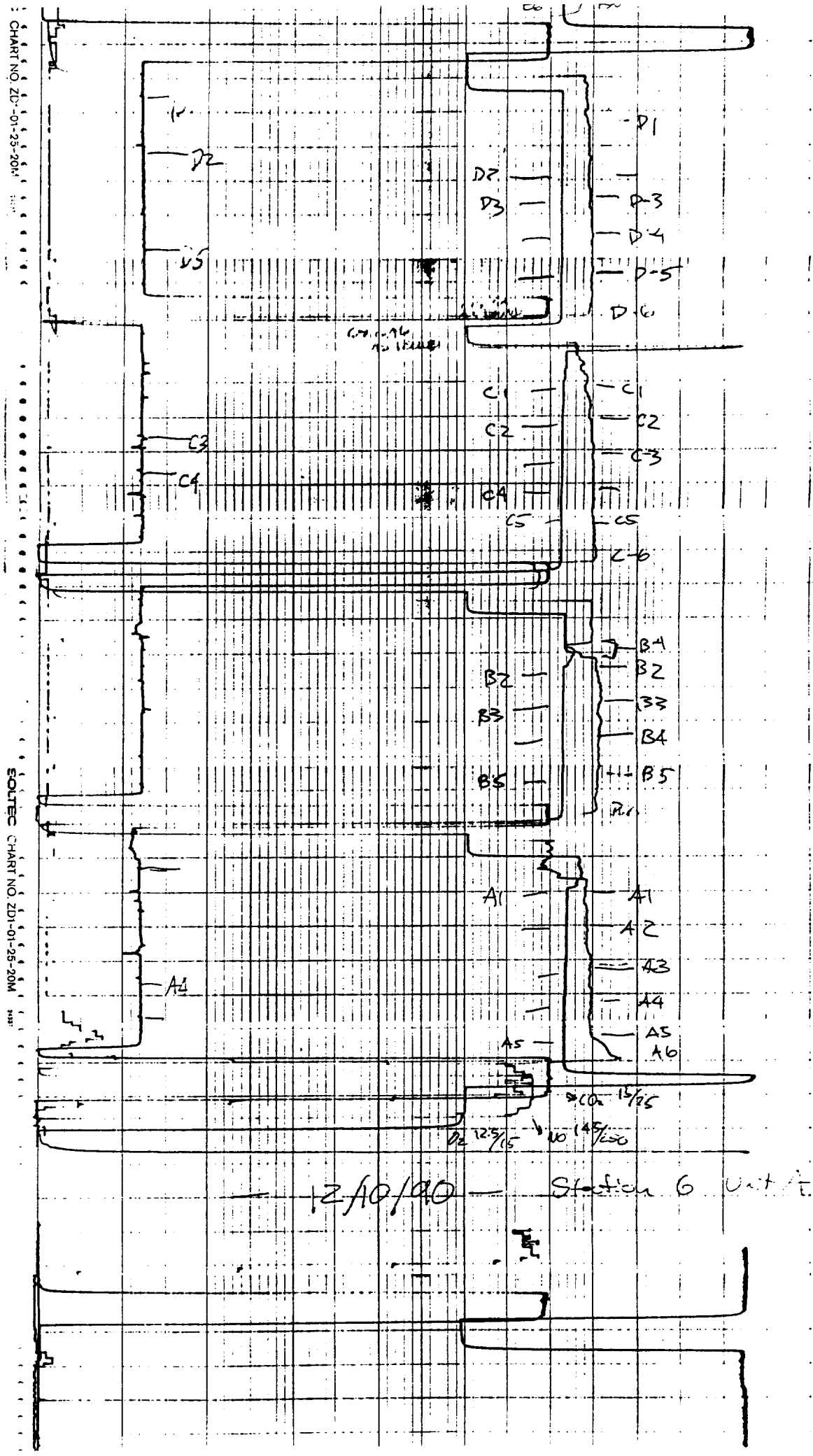
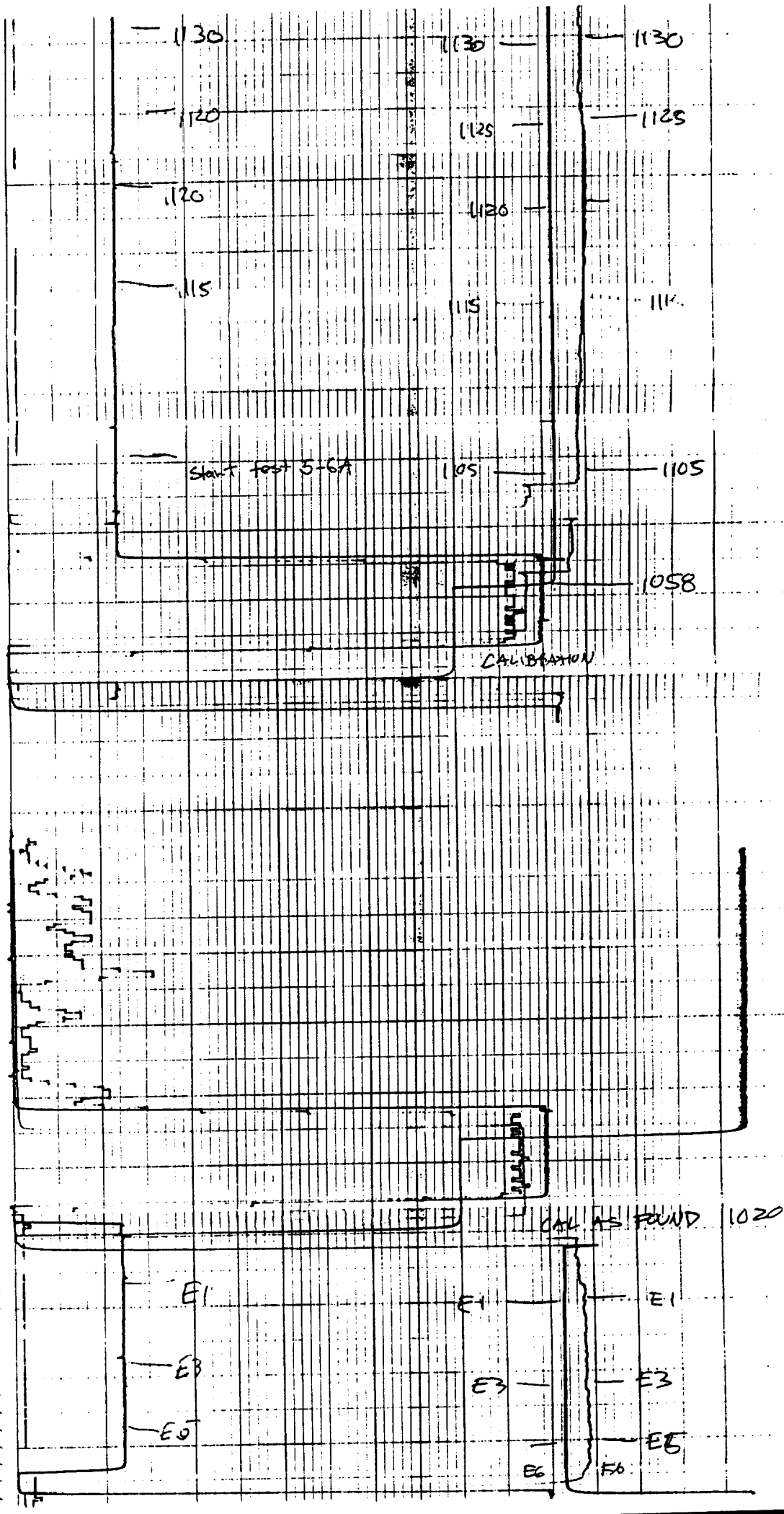
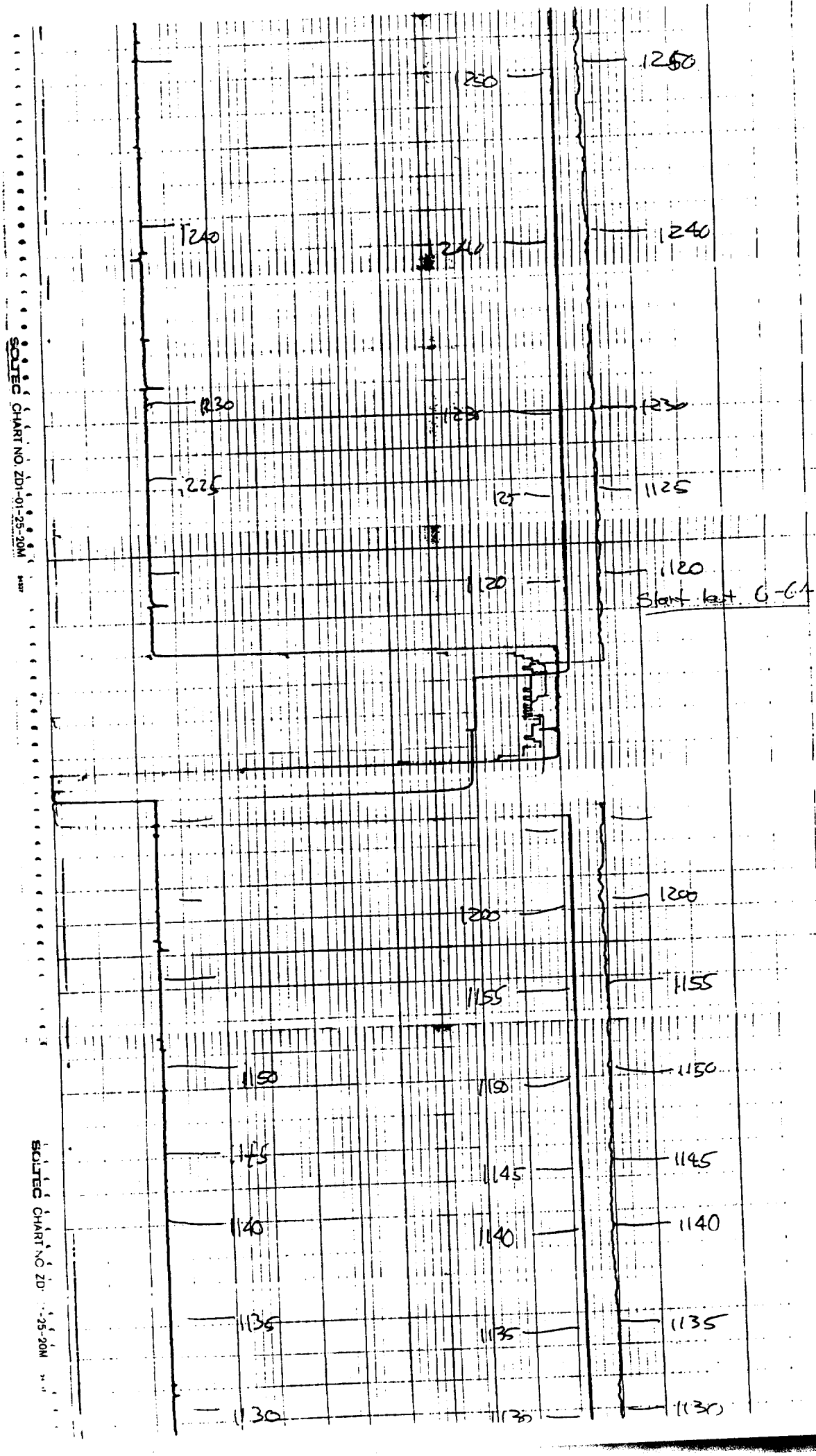
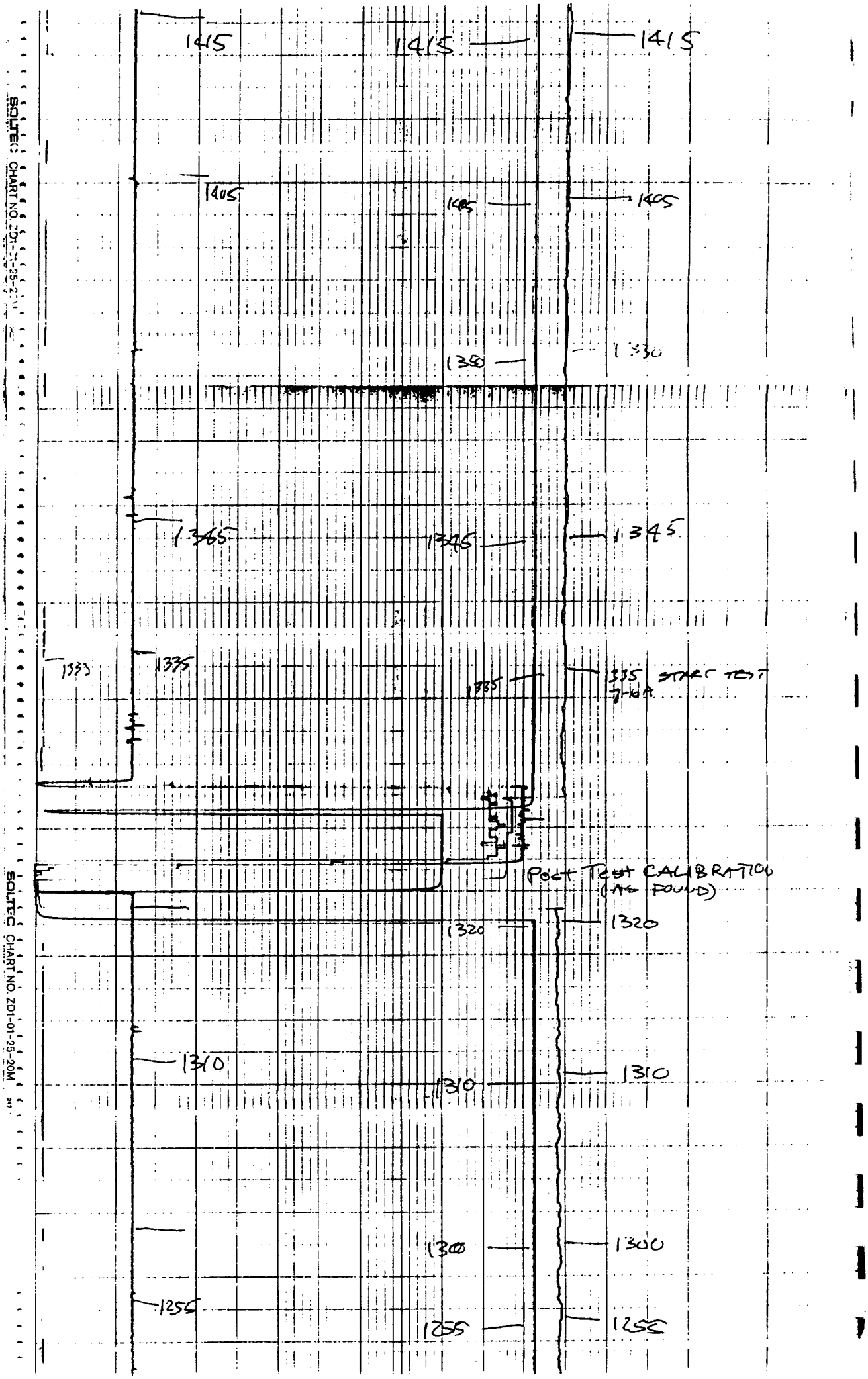
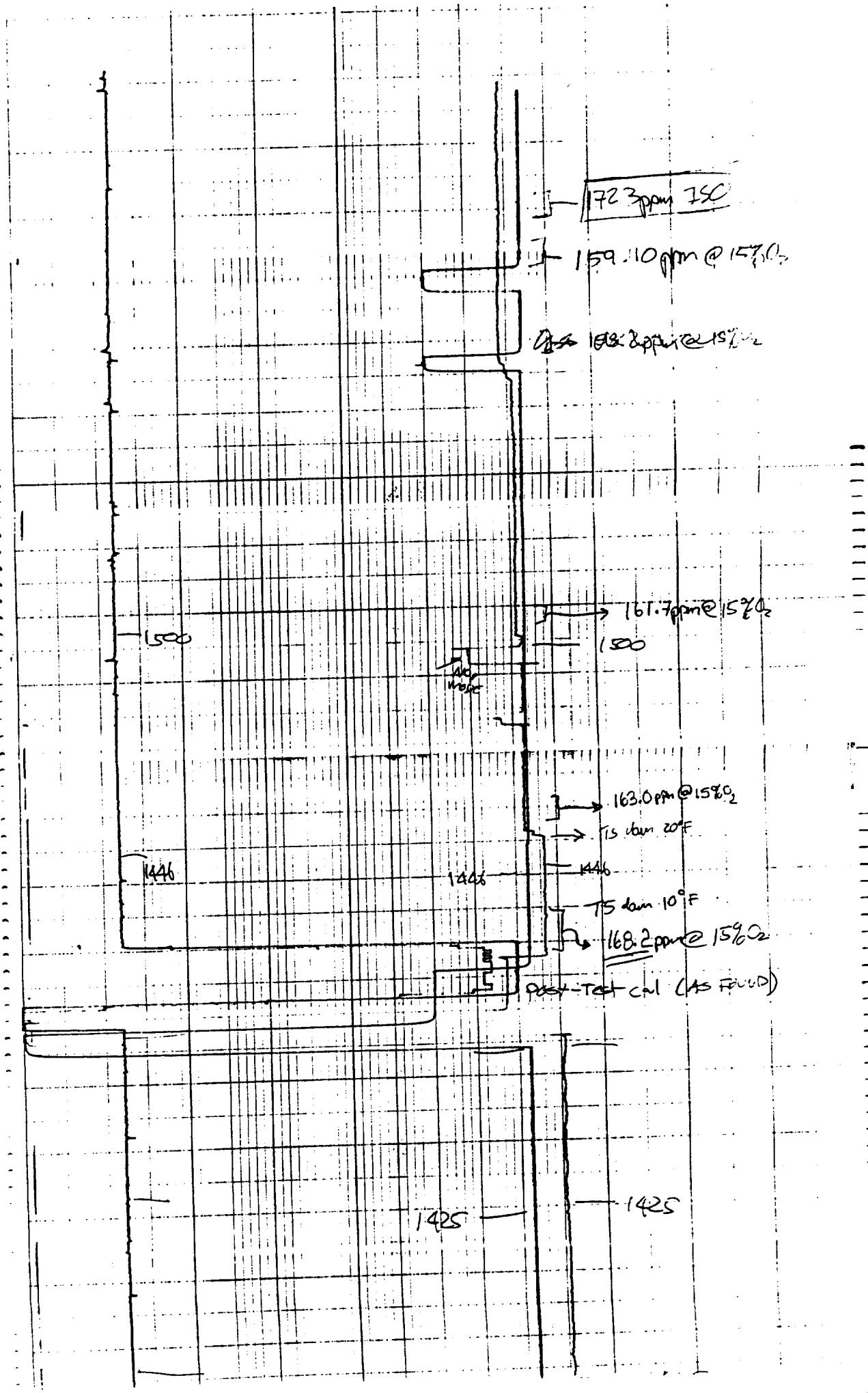


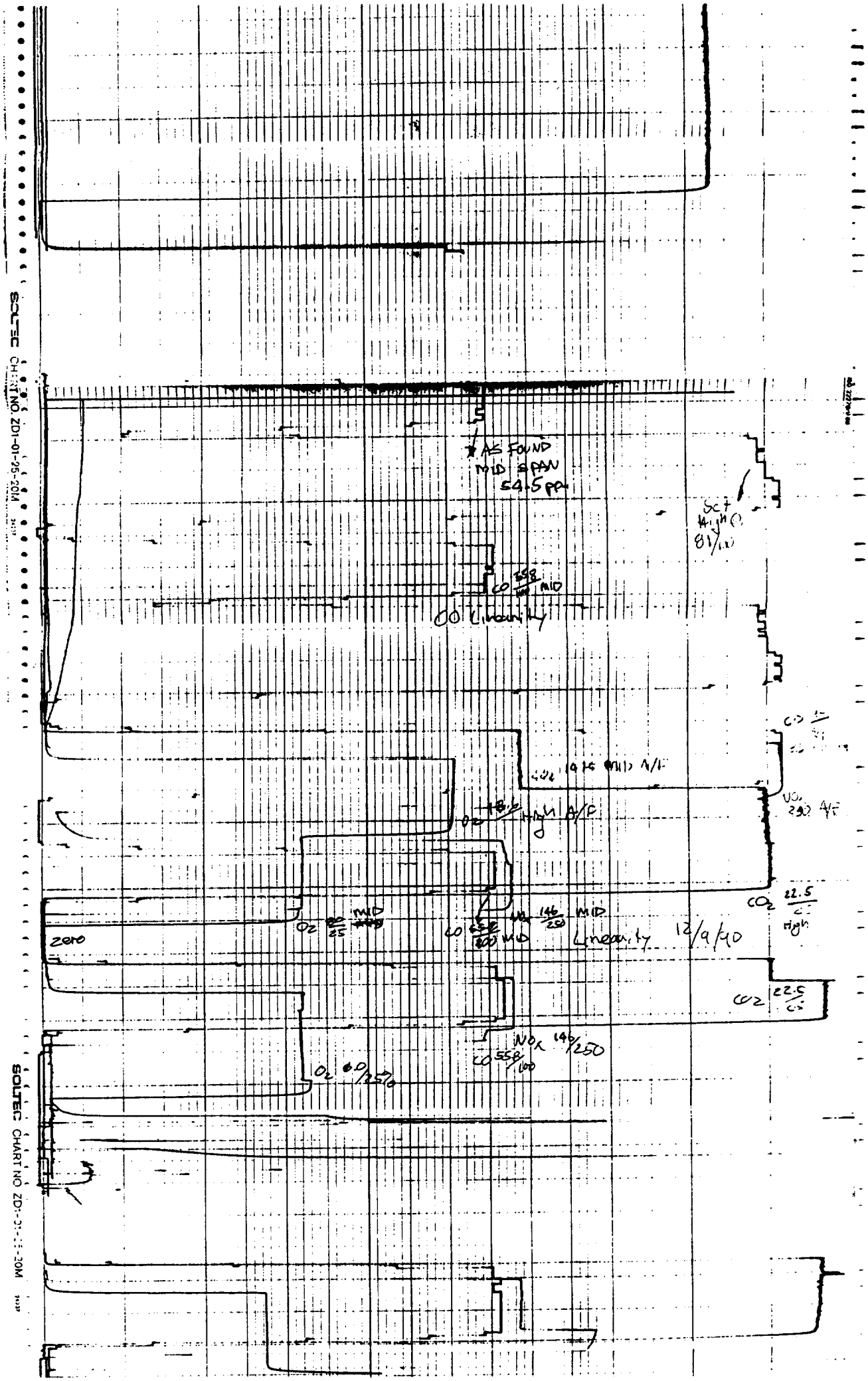
CHART NO. ZD1-01-25-20M
SOLTEC CHART NO. ZD1-01-25-20M


1130
1130
1130
1120
1125
1125
1120
1120
1115
1115
Start test 5-6A
1105
1105
1058
CALIBRATION
CAL AS FOUND 1020
E1
E1
E1
E3
E3
E3
E5
E5
E6
E6
SOLTEC CHART NO. ZD1-01-25-20M


1250
1250
1240
1240
1240
1230
1230
1230
1225
1125
1125
1120
1120
Start last 6-64
1200
1200
1155
1155
1150
1150
1150
1145
1145
1145
1140
1140
1140
1135
1135
1135
1130
1130
1130
SOLTEC CHART NO. ZD1-01-25-20M
SOLTEC CHART NO ZD -25-20M


1415
1415
1415
1405
1405
1405
1350
1330
1365
1345
1345
1335
1335
1335
1335 START TEST
7-6A
POST TEST CALIBRATION
(AS FOUND)
1320
1320
1310
1310
1310
1300
1300
1255
1255
1255
SOLTEC CHART NO. ZD1-01-25-20M
SOLTEC CHART NO. ZD1-01-25-20M


1723 ppm TSC
159.10 ppm @ 15% O2
168.8 ppm @ 15% O2
167.7 ppm @ 15% O2
1500
1500
163.0 ppm @ 15% O2
TS down 20°F
1446
1446
1446
TS down 10°F
168.2 ppm @ 15% O2
post-test cal (AS FOUND)
1425
1425



SOLTEC CHART NO. ZD1-01-25-20M
AS FOUND
MID SPAN
54.5 ppm
CO 558/100 MID
CO Linearity
O2 18.6 High A/F
O2 20/25 MID
CO 558/100 MID
NOx 146/250 MID
Linearity 12/9/90
zero
CO2 22.5
NOx 146/250
CO 558/100
O2 6.0/25%
SOLTEC CHART NO ZD1-01-25-20M

APPENDIX G

LABORATORY RESULTS

CARNOT
LN 42525

12-17-90

Sample ID	Bag 1-Fuel-6A	
COMPONENT	**CONCENTRATION** %v/v	**DL** %v/v
Helium (He)	ND	0.1
Oxygen (O_2)	1.1	0.1
Nitrogen (N_2)	4.1	0.1
Methane (CH_4)	92.2	0.1
Carbon dioxide (CO_2)	0.4	0.1
Ethane (C_2H_6)	1.9	0.1
Propane (C_3H_8)	0.2	0.1
n-Butane (n-C_4H_{10})	ND	0.1
i-Butane (i-C_4H_{10})	ND	0.1
n-Pentane (n-C_5H_{11})	ND	0.1
i-Pentane (i-C_5H_{11})	ND	0.1
Specific Gravity	0.592	
Heat Value, BTU/SCF		
High	972	
Low	876	
Hydrogen Sulfide (H_2S), ppmv	ND	0.1 ppm

ND = not detected
DL = detection limit

CARNOT

SUBJECT Air Correction of Natural Gas Sample JOB NO. _____

SHEET NO. ____ of ____

COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

Component	Concentration		Corrected to 0% O_2
He	ND		ND
O_2	1.1	$-1.1 =$	0.0
N_2	4.1	$-(1.1)(3.76) =$	0.0
CH_4	92.2	$\times \frac{99.9}{99.9-(1.1+4.1)}$	97.3
CO_2	0.4	$\times \frac{99.9}{99.9-(1.1+4.1)}$	0.42
C_2H_6	1.9		2.00
C_3H_8	0.2		0.2
n-C_4H_{10}	ND		ND
i-C_4H_{10}	ND		ND
n-C_5H_{12}	ND		ND
i-C_5H_{12}	ND		ND
	99.9		99.9

O_2 : 1.1 %

N_2 : (1.1)(3.76) = 4.1%

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CARNOT

CERTIFICATION OF SAMPLE RECEIPT

Samples:

P.O.# 6907

Sample No. (Project No. Test No. 87400	Complete Description
1-Fuel-6A	3 bags for
1-Fuel-11A	
1-Fuel-16K1	HHV, composition, H_2S, Sulfur

Chain of Custody Prior to Shipment:

Released by	Time and Date	Received by	Time and Date
[illegible]	12/17/90	[illegible]	12/17/90

Samples shipped to: Trues Dial

Samples shipped from Carnot by: [illegible] Date 12/17/90

Carrier: [illegible] Air Bill No.

Samples received by: Date

Company:

15991 Red Hill Ave., Suite 110, Tustin, California 92680 (714) 259-9520 · FAX (714) 259-0372

LDS-1