PM10 EMISSION FACTORS FOR A STONE CRUSHING PLANT DEISTER VIBRATING SCREEN

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Prepared by:

John Richards, Todd Brozell, and Bill Kirk
Research Division
Entropy Environmentalists, Inc.
P.O. Box 12291
Research Triangle Park, North Carolina 27709-2291

Prepared for:

Solomon Ricks
Emission Measurement Branch
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

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1.0 INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

The U. S. Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS), Emission Inventory Branch (EIB) is responsible for developing and maintaining air pollution emission factors for industrial processes. EIB is presently studying the stone crushing industry. As part of this work, EIB sponsored PM10 particulate emissions tests at Martin Marietta Corporation's facilities in Raleigh-Durham and Garner, North Carolina. The specific sources tested were the tertiary crusher at the Garner plant and a Deister vibrating screen at the Raleigh-Durham plant. This report concerns only the Deister vibrating screen tests. A separate report presents the test results at the tertiary crusher.

The PM10 emission factor test procedures were developed and conducted by Entropy Environmentalists, Inc. (Entropy). The Emission Measurement Branch (EMB) of EPA supervised the test program.

The Deister vibrating screen emission tests were conducted using a track-mounted hood system. The hood has dimensions of 2 feet by 2 feet and was mounted 12 inches above the upper screen deck of the Deister Screen. The small scale and the mounting position of the hood ensured that the normal PM10 emissions were not significantly influenced by the presence of the hood. The capture velocity in the hood was set by adjusting the variable speed DC motor of the tubeaxial fan installed on the hood outlet duct. The hood capture velocity was selected based on observations of the fugitive dust capture characteristics of the hood. A constant gas flow was used throughout the test program. This testing approach is an adaptation of the conventional "roof monitoring" technique for fugitive emission testing.

The PM10 emissions were tested using EPA Method 201A. The tests were divided into two sets: stone moisture levels greater than 1.5%, and stone moisture levels less than 1.5%. These criteria were used based on limited data concerning moisture requirements of wet suppression systems for fugitive dust[1,2]. It was necessary to operate a continuously recording meteorological station next to the Deister to characterize the wind speed and direction during the tests. A set of two ambient PM10 monitors was operated on the upwind side of the Deister screen in order to determine the ambient levels entering with the wind. The observed PM10 emission levels were adjusted to account for the PM10 levels caused by other sources in the facility and in the general area. The results of the PM10 tests are summarized in Table 1-1.

TABLE 1-1. VIBRATING SCREEN PM10 EMISSIONS

PM10 Emissions, Pounds/Ton[1]		
Dry Stone (< 1.5%)	0.00618	(Without Control)
Wet Stone (> 1.5%)	0.00054	(With Controls)

[1]Based on total stone feedrate from surge pile.

The emission rates determined during both series of tests on the Deister screen were low. These data are entirely consistent with the general observations of the plant operation and with the no visible emission conditions during all of the wet stone tests. Stone samples obtained during each tests were also analyzed and found to have very low levels of material below approximately 70 microns.

1.2 KEY PERSONNEL

The U. S. EPA EIB Project Manager for this project was Mr. Dennis Shipman. Mr. Solomon Ricks served as the U. S. EPA EMB Project Manager. Mr. Dennis Holzschuh provided technical assistance to Mr. Ricks. The Entropy Project Manager was Dr. John Richards, P.E. He was assisted by Mr. Todd Brozell and Mr. Bill Kirk. Mr. Horace Wilson and Mr. Steve Witt of Martin Marietta coordinated testing schedules with the plant personnel and provided operating data. A summary of the key personnel and their phone numbers are provided in Table 1-2.

TABLE 1-2. KEY PERSONNEL

	Telephone Numbers
U. S. Environmental Protection Agency	
Emission Inventory Branch	
• Mr. Dennis Shipman	(919) 541-5477
Emission Measurement Branch	
• Mr. Solomon Ricks	(919) 541-5254
• Mr. Dennis Holzschuh	(919) 541-5254
Martin Marietta Corporation, Inc.	
• Mr. Horace Wilson	(919) 781-4550
• Mr. Steve Witt	(919) 781-4550
Entropy Environmentalists, Inc.	
• Mr. John Richards	(919) 781-3551
• Mr. Todd Brozell	(919) 781-3551
• Mr. Bill Kirk	(919) 781-3551

2.0 PLANT AND SAMPLING LOCATION DESCRIPTION

2.1 PROCESS DESCRIPTION AND OPERATION

The Raleigh-Durham plant produces crushed granite used for construction and road paving. Figure 2-1 is a flowchart of the portion of the Raleigh-Durham plant relevant in this project. The figure was prepared based on a drawing labelled "Plant 632 Flow Diagram" provided by Martin Marietta.

Rock blasted from various locations in the quarry is trucked (stream 1) to a primary crusher. A large surge pile is used to provide a steady flow of stone to the plant processing equipment located adjacent to the quarry. An 8 foot by 420 foot conveyor (stream 3) is used to deliver the stone to the vibrating deck above the secondary crushers. Martin Marietta monitors the stone feed rate from the surge pile by means of a load cell type weigh belt scale near the discharge end of this conveyor. This instrument is used as the indicator of plant production rates. Normal production rates range from 500 to 700 tons per hour.

The scalping screen serving the secondary crushers removes less than 1.5 inch material produced during blasting or during primary crushing. This less than 1.5 inch material is conveyed (stream 4) to a separate storage pile and are sold as product. Typical stone flow levels in stream 4 are estimated at 80 tons per hour by Martin Marietta personnel.

Two cone-type secondary crushers reduce the size distribution of the material received from the surge pile. Stone leaving the secondary crushers ranges in size from 6 inches to relatively small particles. The material from both secondary crushers discharges onto a conveyor (stream 9) leading to the tertiary crusher inlet. The tertiary crusher discharge stream (stream 16) also discharges onto this conveyor (now labelled stream 10). Following the tertiary crusher discharge, the main feed conveyor (stream 10) contains all of the plant production with the exception of the fines discharge stream discussed earlier. The main feed conveyor stream passes through a transfer station and delivers the stone to the top of the structure housing the Deister vibration screens and the Omnicone tertiary crusher. The stone flow to the Deister screens and tertiary crusher is termed "closed circuit" since oversized material containing some fines adhering to the surface can recirculate through the Deister and tertiary crusher[3].

At the conveyor discharge point, the stone feed splits into two streams which lead to the East and West screens. In order to check the adequacy of the weigh belt scale as a production rate monitor, Entropy measured the stone feed rate to the Deister screen being tested by collecting and weighing a 2 foot sample of stone at a point just upstream of the conveyor discharge. Point B on Figure 1 is the conveyor (stream 10) monitoring location.

The Deister decks are 7 feet wide by 20 feet long and are inclined on a 20 degree slope. There are three vertically stacked decks. The upper deck has a mesh opening of 1.125 square inches, for the first 12 feet of travel and an opening of 1 square inch for the last 8 feet of travel. The middle deck has mesh opening of 0.58 square inches and the lower deck has slot openings of 0.118

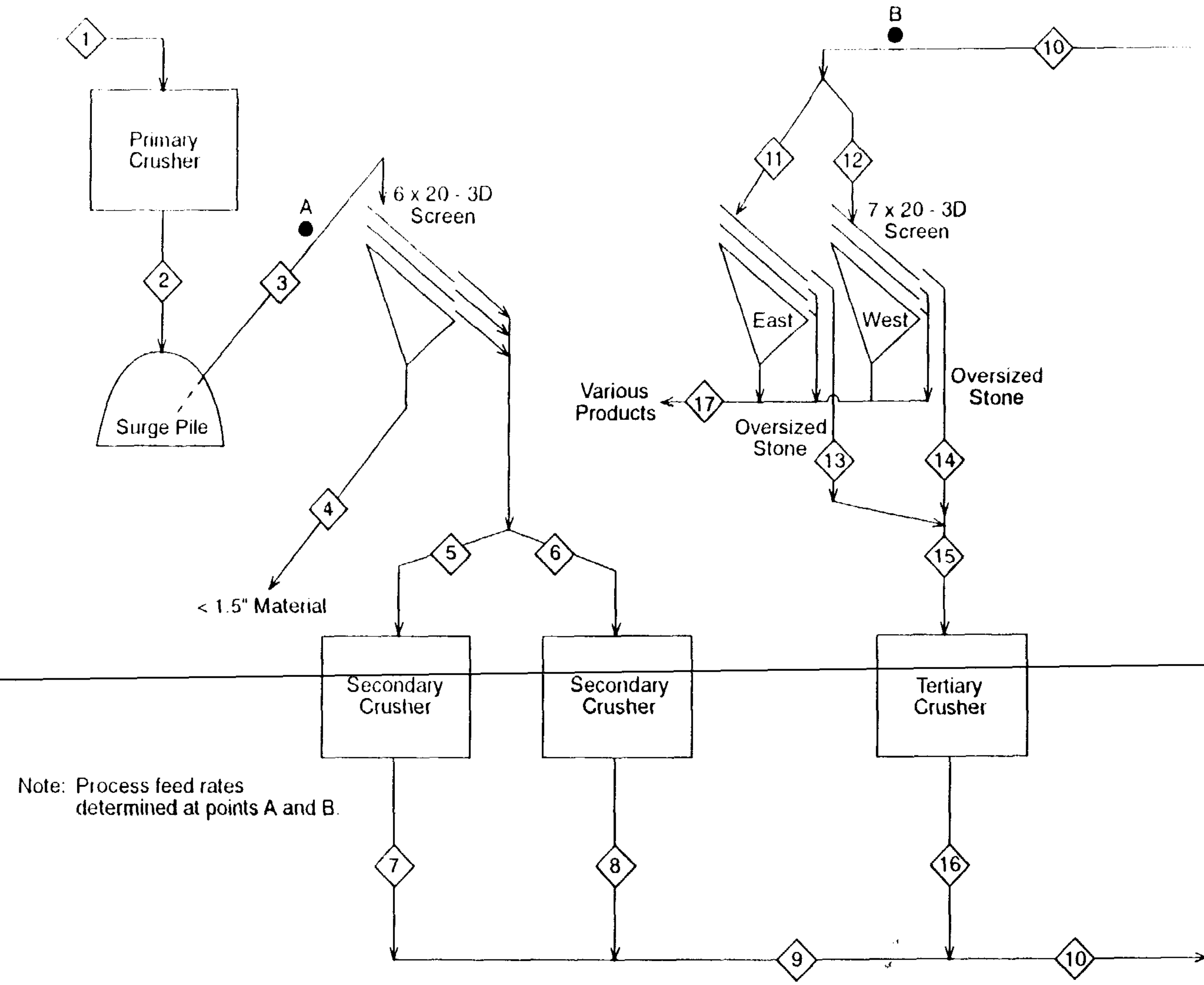

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Figure 2-1. Simplified flowchart Raleigh-Durham plant.

inches by 1 inch. Stone collecting on the middle and lower decks are combined as one product stream. Fine particles passing through all three decks collect as a separate process stream. Both of these sized product streams are designated together as "stream 17" in Figure 2-1. The oversized material remaining on the top screen goes to the inlet of the tertiary crusher. The total quantity of oversized material entering the Tertiary crusher is estimated to be 300 to 400 tons per hour. The stone feed rates to the two Deister screens were approximately equal during the tests.

The plant operates approximately 200 days per year. The typical operating times are 7 a.m. to 5:00 p.m. each day. Total production quantities per year are approximately 1,000,000 tons.

2.2 FUGITIVE DUST CONTROL

Wet suppression is used for fugitive dust control of the Deister vibrating screens. There are water spray nozzles located on the conveyor underneath the tertiary crusher (beginning of stream 10), at the stream 10 conveyor transfer point, at the top of the stream conveyor above the Deister screens, and on the discharge chute near the top of the Deister screens. Not all of these spray nozzles are necessary to maintain wet conditions. The nozzles on the inlet chute to the Deister screen were off during the tests.

Over-wetting of the rock can cause blinding of the lower screen or blockage of the fines discharge chute underneath the Deister[4,5]. During these emission tests, the plant experienced no significant screen blinding conditions. However, the wet stone condition test coupled with heavy overnight rains on several test days caused some blockages of the fines discharge chute.

2.3 SAMPLING AND EMISSION TESTING PROCEDURES

2.3.1 Fugitive Emission Capture Systems

Since there is not an air pollution control device on the Deister screens, a fugitive emission capture system is needed to capture the particulate matter leaving the upper screen. Entropy considered the criteria listed in Table 2-1 in designing the fugitive emission capture system. Entropy evaluated alternative capture systems during several site visits by Entropy and U. S. EPA personnel. The alternative capture techniques which are generally applied to fugitive dust emission sources include[6,7]:

- Quasi-stack
- Roof monitor
- Upwind-downwind profiling

The quasi-stack method involves the construction of a temporary enclosure around the Deister screen and the installation of a duct and fan system for gas handling. Entropy rejected this approach primarily because of the extremely high gas flow rates necessary. Observations of dust emissions made during the pretest visits indicated that wind flowing across the 6- to 24-inch zone above the

Table 2-1. FUGITIVE EMISSION CAPTURE SYSTEM DESIGN CRITERIA

- The capture system should not create higher-than-actual PM10 emission rates due to high gas velocity conditions near the upper Deister screen, near the stone inlet chute, or near the upper screen discharge chute.
- The capture system should not create a sink for PM10 emissions due to particulate losses.
- The capture system should isolate the Deister screen being tested (west unit) from the adjacent unit (east unit).
- The capture system should not create safety hazards for the emission test crew or for plant personnel. It should not create risks to the plant process equipment.
- The capture system should not obstruct routine access to the process equipment by plant personnel.
- The capture system and overall test procedures must be economical, practical, and readily adaptable to other plants so that these tests can be repeated by organizations wishing to confirm or challenge the emission factor data developed in this project.

Deister side wall was being caught in swirling gas flow patterns and influencing the emission rates. To simulate the identical emission conditions for typical wind speeds at the plant would require gas flow rates between 13,200 and 52,800 actual cubic feet per minute (ACFM). Ductwork with a diameter between 4 and 6 feet would be necessary to carry this large gas flow at velocities where PM10 losses would be minimized. Since the Deister vibrating screen is on a relatively small platform 80 feet above the ground, this ductwork would have to be quite long and carefully supported. This approach would be prohibitively expensive. Other disadvantages include:

- It would be extremely difficult to simulate actual wind speeds and wind approach angles using make-up air.
- An enclosure above the vibrating screen represents a risk to to equipment since rain and occasional rocks from the overhead conveyor could overweight the structure.
- An enclosure restricts plant operations personnel's access to the vibrating screen
- Construction safety risks are possible due to the lack of access and due to the rotating equipment in restricted areas.

Based on the site visits, Entropy concluded that a quasi-stack approach similar to the one used at the Garner Plant tertiary crusher (see the Entropy report dated February 7, 1991) was uneconomical and potentially unsafe.

Emission profiling techniques involve measurement of the increase in PM10 concentrations as a gas stream passes over or around the source being evaluated. This is usually performed using ambient PM10 monitors in upwind and downwind locations. Entropy concluded that this approach was not applicable to the Deister screen at the Raleigh-Durham plant. The platform with the Deister screen had two separate units, only one of which was being tested. Furthermore, there were a number of sources immediately upwind and downwind of the Deister screens. It would be impossible to isolate one or both of the Deister screens from these nearby sources. These included:

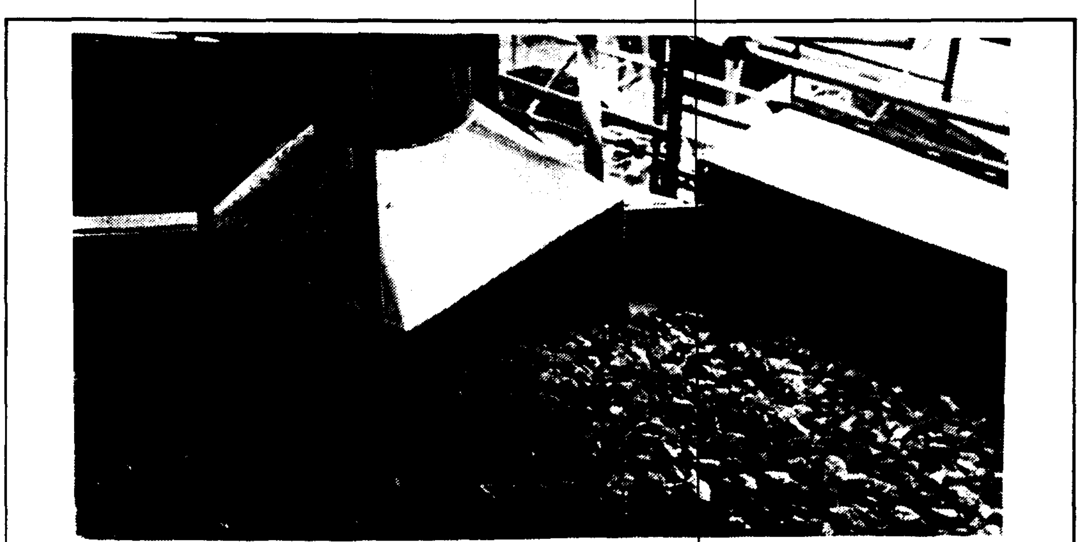
- Vehicle traffic around the tertiary crusher and screens
- Tertiary crusher and secondary crushers
- Various conveyors and stone transfer points
- Air traffic approaching and leaving Raleigh-Durham airport.

The emission profiling approach was not practical due to the number of potential PM10 sources and their locations near the Deister screens.

The roof monitoring approach of fugitive emission capture appeared to be the most applicable technique available for the Deister screen at the Raleigh-Durham plant. This involved the sampling at a horizontal array of sampling points above the surface of the emission source. However, an adaption of the general procedure was necessary due to the lack of a partial enclosure to serve as the roof monitor and due to the swirling gas flows created by ambient winds. Accordingly, Entropy designed and installed a track-mounted hood system for fugitive emission capture.

The track-mounted hood system consisted of a 2 foot by 2 foot aluminum hood suspended 12 inches above the upper deck of the Deister vibrating screen. The position of the hood above the stone is shown in Figure 2-2.

Figure 2-2. Hood Assembly



This position was close enough to ensure good emission capture but not so close that the entering air stream caused greater-than-actual emissions. A variable speed DC-driven tubeaxial fan controlled the capture velocity of the air entering the hood. This velocity was set at 150 feet per minute based on the hood capture characteristics observed using smoke and lightweight strips of fabric. This velocity is higher than the 50 feet per minute minimum velocity specified in reference 9 for vibrating screens.

Two side views of the hood are shown in Figure 2-3 (Next Page). One side of the hood opening angled 20 degrees to match the slope of the Deister screen. The duct carrying the air and particulate matter had a one radius 90° turn and was attached to a flexible duct leading to the emission sampling location. The hood and support rails were supported on a carriage that spanned the Deister screen. One side of this carriage is shown in Figure 2-4. During the emission tests, the carriage moved downward along the side rails also shown in Figure 2-4. The side rails were attached to four sets of scaffolding erected at each corner of the Deister.

The top area of the Deister screen was divided into a 3 by 9 array of sampling locations, each of which was 2 feet by 2 feet in size. The only area not sampled was the 2-foot strip across the upper inlet side of the Deister screen. Traversing this area was not possible due to the presence of the inlet chute and the stone flow pattern approaching the top screen.

Figure 2-4. Carriage System

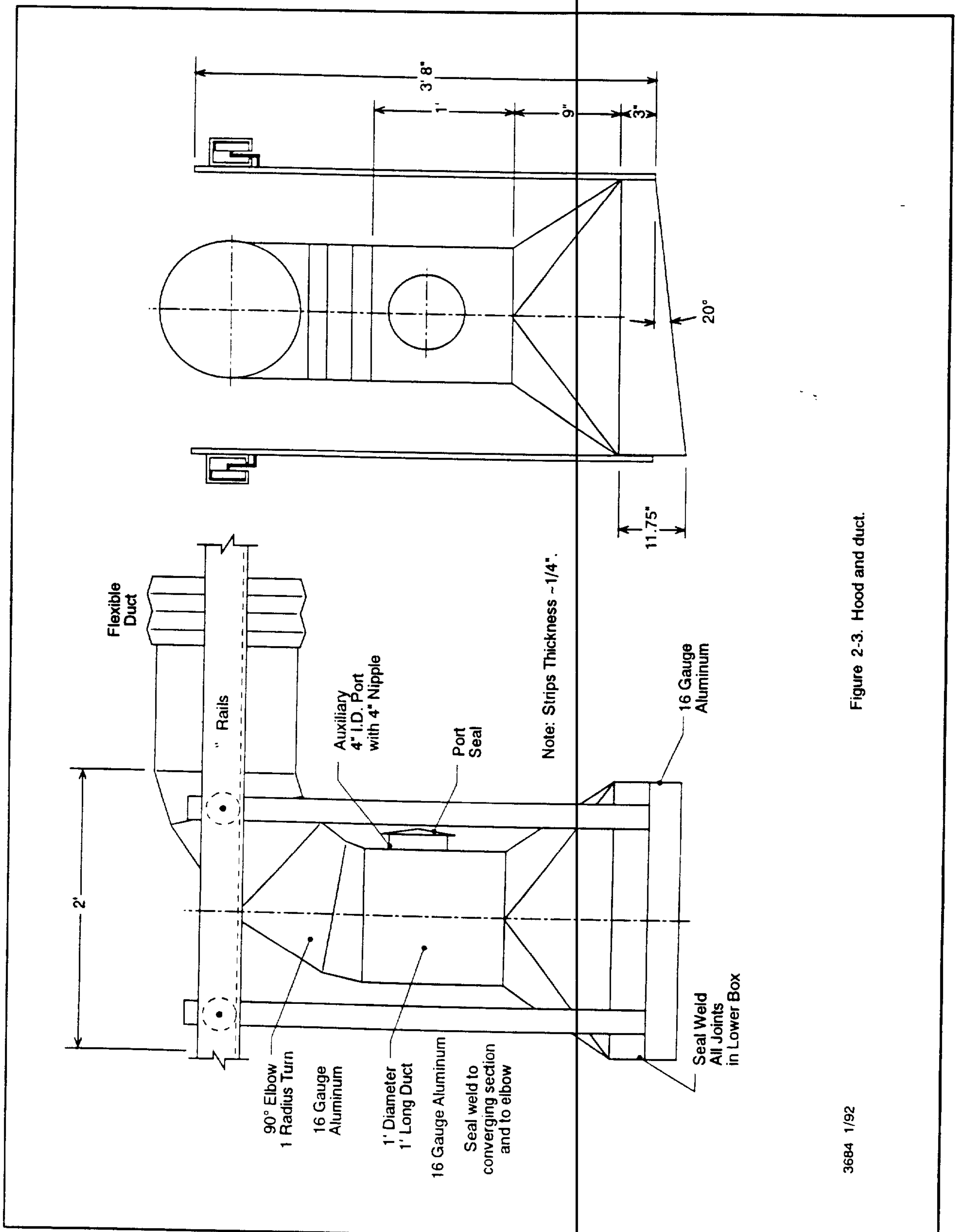


Figure 2-3. Hood and duct.

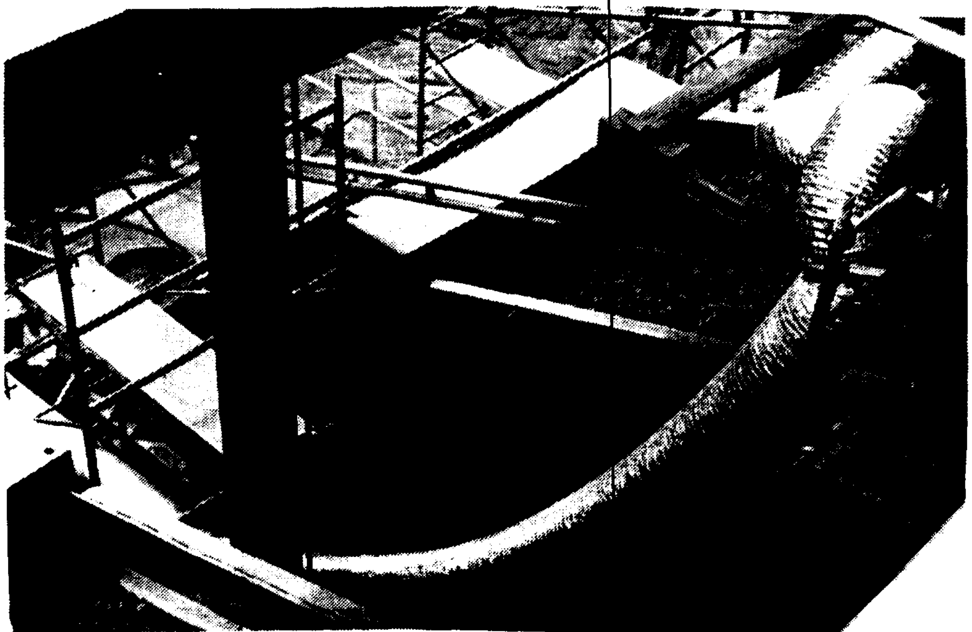


Figure 2-5. Flexible Duct System

Entropy sized the ductwork from the hood to the sampling location for an average gas flow rate less than 1000 feet per minute. This transport velocity is well below the 3500 to 4500 feet per minute velocity used to size commercial ductwork in stone crushing plants and other facilities handling large diameter dusts[2,8]. The purpose of the high velocities in commercial ducts is to ensure that dust does not settle and accumulate in the ductwork over long time periods. The flexible duct system is shown in Figure 2-5. Dust accumulation was not a problem during this study since the hood operating times were relatively short and the flexible duct was cleaned regularly. The 1000 feet per minute duct velocity limit is advantageous since this limits the impaction of particles less than 10 microns on the side walls of the hood elbow and the side walls of the flexible duct. Also, the low transport velocity limits any reentrainment of dust which does settle in the flexible duct.

2.3.2 PM10 Emission Testing Procedure

EPA Reference Method 201A was used to monitor the PM10 emissions from the Deister screen. The complete sampling train is shown in Figure 2-6. This consists of: (1) a sampling nozzle, (2) a PM10 sampler, (3) a probe and umbilical cord, (4) an impinger train, and (5) flow control system. Due to the relatively small duct and the constant sample gas flow rates set using the DC-driven tubeaxial fan, the "S"-type pitot tube was not mounted on the PM10 sampler probe. Gas velocities were determined prior to the emission tests.

Particulate matter larger than 10 microns in diameter is collected in the cyclone located immediately downstream of the sampling nozzle. Particulate smaller than 10 microns is collected on the outlet tube of the cyclone and on the downstream glass-fiber filter. A disassembled PM10 sampling head is shown in Figure 2-7.

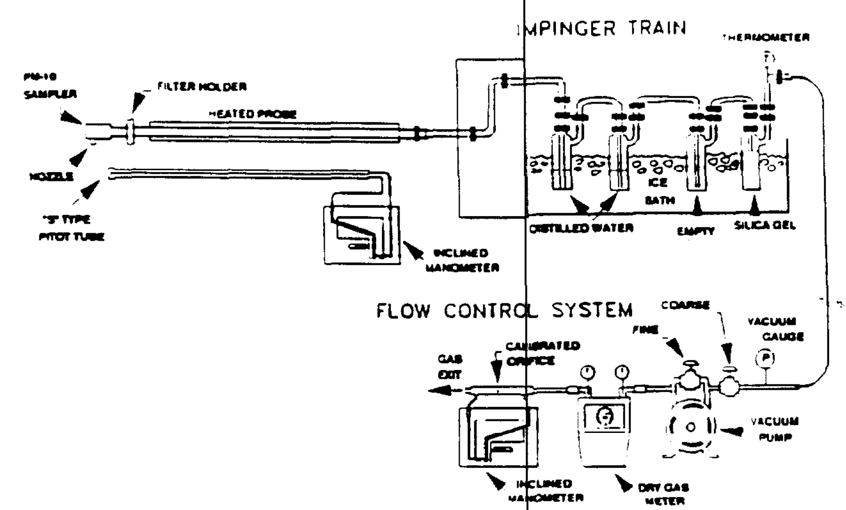


Figure 2-6. M201A Sampling Train

The cyclone and filter system used in this study met the design and sizing requirements of Section 5.2 of Method 201A. The gas flow rate through the cyclone was set based on the orifice pressure head equation provided in Figure 4 of Method 201A. The gas flow rate was kept constant throughout the emission test program.

PM10 sampling was performed in a 1-foot diameter smooth wall duct mounted horizontally across the elevated platform housing the Deister vibrating screen. The 1 foot diameter duct was connected to the flexible duct leading from the track-mounted hood. The 4-inch diameter sampling port was located 10 feet downstream of the flexible duct connection and 2 feet upstream of the fan. Four traverse points in the horizontal direction were sampled. Sampling in the vertical direction across the duct was not possible since dust collected in the cyclone could be resuspended and pass through to the filter. The cyclone and nozzle assembly were mounted within the duct during sampling. A heating mantle was used around the filter to keep temperatures approximately 50 degrees Fahrenheit above the stack temperature. This was necessary to avoid filter blinding due to moisture condensation in the sampling train.

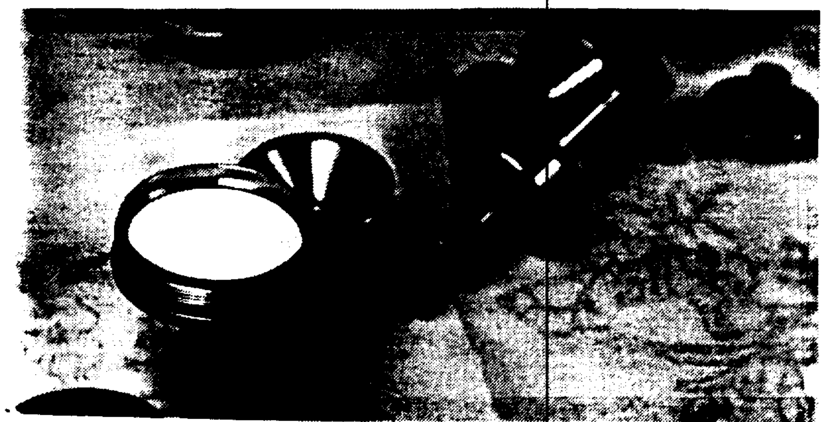


Figure 2-7. Dissassembled PM10 Sampling Head

The particulate samples were recovered using the procedures specified in Method 201A. The sample recovery scheme is illustrated in Figure 2-8. The material from the filter, cyclone outlet tube, and filter inlet housing were combined to determine the total PM10 catch weight.

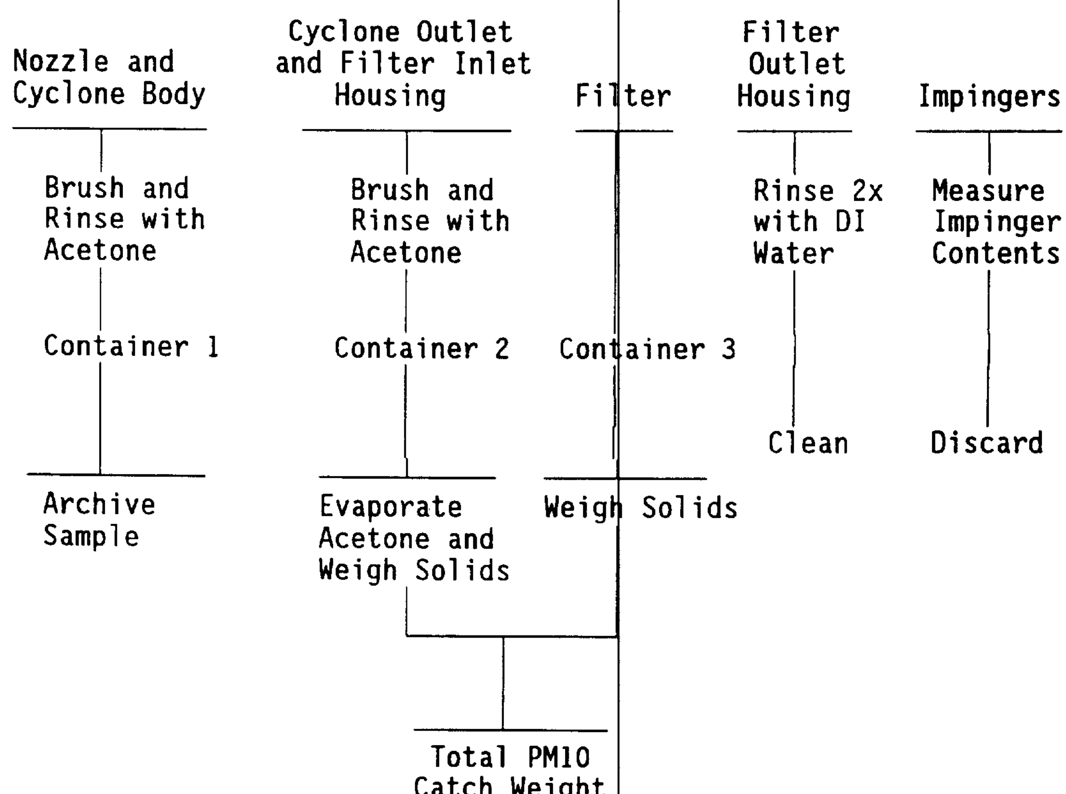


Figure 2-8. Sample Recovery

2.4 MONITORING OF PROCESS OPERATING CONDITIONS

There are a number of process variables and weather conditions which could conceivably influence PM10 emission rates from the Deister screen[3,1]:

- Stone moisture level
- Ambient wind speed
- Wind direction
- Stone size distribution
- Stone silt content
- Deister stone feed rates
- Stone type (breaking characteristics)
- Stone hardness and density

All of these variables with the exception of stone type were monitored using a combination of plant instruments, special monitoring equipment, and stone sample analyses. Stone type was not monitored since granite is the only type of stone processed at this plant. Samples of the stone were archived to permit future analyses if necessary.

2.4.1 Stone Moisture Level

A stone sample was removed during each of the emission tests. In most cases, this sample consisted of a 2 linear foot sample of stone from the main conveyor feeding the Deister screen. The conveyor was stopped by plant personnel for approximately 5 minutes to permit the Entropy test crew to remove the stone sample. The sample was placed in a sealed plastic bucket. Each sample weighed more than 120 pounds.

A sample was selected for analysis by placing the stone in a pile and dividing it into four quadrants. The quadrant randomly selected for analysis was further subdivided in quadrants until the sample quantity was less than approximately 2 pounds. This sample was then weighed and heated in an oven at a gas temperature of approximately 250 degrees Fahrenheit. The weight loss during heating was calculated and reported as the stone moisture level.

2.4.2 Wind Speed and Direction

An Entropy-supplied weather station was mounted on the platform directly above the Deister screens. Data were recorded on a dedicated microcomputer on a minute-by-minute basis. This system was necessary since wind speed and direction strongly influenced visible dust emission rates. Data provided by the weather station at the airport (located approximately 2 miles to the west) were not entirely representative of the localized wind conditions. The location of the weather station sensors is shown in Figure 2-9.

2.4.3 Ambient PM10 Levels

Two ambient PM10 monitors were operated directly upwind of the Deister screen. These were operated only during the time periods that PM10 emission sampling was in progress. The ambient air flow rates through the samplers were calibrated

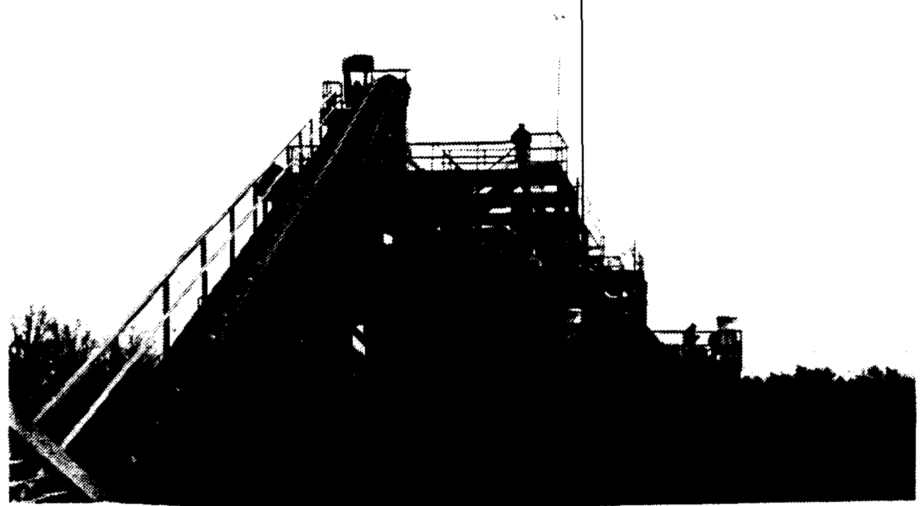


Figure 2-9. Location of Meteorological Station

calibrated using an Airdata micromanometer. The filters were weighed and PM10 levels during the test were calculated. The locations of the two ambient PM10 samplers are also shown in Figure 2-9.

2.4.4 Stone Size Distribution and Silt Content

Samples of the stone obtained during the test (see Section 2.4.1) were used to determine the size distribution and silt content. One of the initial sample quadrants not used for moisture analysis was further subdivided for analysis by ASTM sizing screens. A sample of approximately 2 pounds was loaded into the top pan. The screens used included:

- 1.5 inch screen
- 0.75 inch screen
- No. 4 screen (mesh opening 0.187 inches)
- No. 20 screen (mesh opening 0.033 inches)
- No. 100 screen (mesh opening 0.0059 inches)
- No. 200 screen (mesh opening 0.0029 inches)
- Bottom pan

The loaded ASTM screens were placed in a Ro-TAP shaker and processed for 10 minutes. The weights of stone remaining on each of the screens were then determined by subtracting the screen tare weights from the loaded weights.

The data provided by the ASTM sizing screens provided information on the "as-sampled" stone size distribution. Following this analysis, of the ASTM screens with sample was placed into an oven and heated to 250°F until dry. Then the ASTM screens were restacked and shaken for 10 minutes. The dry weights per screen were then used as an indication of the total silt content of the stone which could conceivably be released while the stone is being processed on the Deister screens.

2.4.4 Stone Processing Rates

The stone processing rate of the Deister screen has been defined by Entropy as the total quantity of stone produced by the plant minus the fines removed prior to the secondary crusher. The actual quantities of stone passing through the Deister are considerably higher than this value since all of the oversized material remaining on the top deck of the Deister is sent to the tertiary crusher and then returned to the Deister screen. The quantities of stone in stream 10 shown Figure 2-1 are approximately 60% higher than the quantity in stream 3 due to this recycle loop. This recycle estimate is based on measurements of the stone feed rates on the top conveyor discharging stone to the two Deister screens.

The secondary feed weigh belt scale has been chosen as the basis for the production rate definition since these data are most readily available at other stone crushing plants. Furthermore, this value is most representative of the total quantity of fines passing through the Deister screen. The disadvantage of this definition is that it creates emission factor values in pounds per ton of stone, which are higher than would be calculated if the production rate were based on the total feed rate.

The stone processing rate calculation at the Raleigh-Durham plant tested during this study is further complicated by the presence of two Deister screens operated in parallel. Because of the configuration of the equipment there is no quantitive means to determine the separate stone flow rates to each. Entropy has based on emission factor calculations of a 50%-50% split based on observations during the emission tests.

3.0 TEST RESULTS

3.1 OBJECTIVES AND TEST MATRIX

The objective of this test program was to determine the PM10 emission factors for a Deister vibrating screen at a stone crushing plant. The test program concerned both wet and dry stone conditions. The specific objectives included the following:

- Capture the PM10 emissions from the Deister vibrating screen without significantly affecting the emission rate.
- Determine the PM10 emission concentrations by means of EPA Reference Method 201A.
- Calculate the total PM10 emission rates using the known hood gas flow rates and the Method 201A emission concentrations.
- Measure the stone moisture content, stone feed rate, stone size distribution, stone silt content, wind speed, wind direction, and ambient PM10 concentrations.

Table 3-1 presents and sampling and analytical matrix and sampling log for the testing at the Martin Marietta Corporation Raleigh-Durham plant.

3.2 FIELD TEST CHANGES AND PROBLEMS

Entropy had originally planned to use the conveyor No. 5 stone sample weights and conveyor speed to calculate the stone feed rate to the Deister. However, during the initial tests at the plant, it became readily apparent that the stone quantities and characteristics varied considerably even over relatively short time periods. Accordingly, a single 2 linear foot sample representing approximately 0.3 seconds of feed time was not necessarily representative of the average conditions throughout the 1 hour to 6 hour emission test. Accordingly, Entropy based the production rate estimates on the continuous data available from the plant's weigh belt scale rather than the single, short term value from the conveyor samples.

During most of the tests, the facility experienced a number of short term production interruptions. Most of these resulted from pluggage of the fines chute directly below the Deister screen. On December 20, 1991 there was an extended plant outage due to failure of one of the two secondary crushers. The Method 201A sampling trains were shut down during all production outages. Sampling resumed approximately 2 to 5 minutes after production rates, and stone characteristics returned to normal conditions. The times and durations of these production rates can be determined by examining the weigh belt scale recording charts reproduced in Appendix A to this report.

TABLE 3-1. SAMPLING MATRIX

Run No.	Test Type	Date	Time	Test Method	Sampling Location
1	Dry	12-17-91	12:30	Method 2	Outlet Duct
			13:20-14:33	Method 201A	Outlet Duct
			14:20	Stone Sample	Conveyor 5
			12:30-15:00	Ambient PM10	Deister Platform
			13:00-15:00	Wind Conditions	Deister Platform
2	Dry	12-19-91	12:20-13:47	Method 201A	Outlet Duct
			11:57-15:35	Ambient PM10	Deister Platform
			12:20-15:32	Wind Conditions	Deister Platform
3	Dry	12-19-91	14:05-15:17	Method 201A	Outlet Duct
			11:57-15:35	Ambient PM10	Deister Platform
			12:20-15:32	Wind Conditions	Deister Platform
			16:10	Stone Sample	Conveyor 5
4	Wet	12-20-91	10:40-13:28	Method 201A	Outlet Duct
			10:20-14:00	Ambient PM10	Deister Platform
			10:40-13:28	Wind Conditions	Deister Platform
			14:45	Stone Sample	Conveyor 5
5	Wet	01-02-92	08:48-15:34	Method 201A	Outlet Duct
			08:55-15:45	Ambient PM10	Deister Platform
			08:48-15:34	Wind Conditions	Deister Platform
			14:20	Stone Sample	Conveyor 5
6	Wet	01-06-92	08:11-14:50	Method 201A	Outlet Duct
			08;05-14:35	Ambient PM10	Deister Platform
			08:12-16:37	Wind Conditions	Deister Platform
			10:50,13:28	Stone Samples	Conveyor 5

During the first test conducted on December 17, 1991 at the Raleigh-Durham plant, Entropy attempted to use a small movable scaffold to suspend the track-mounted hood. The scaffold was designed to minimize the amount of equipment that had to be hoisted to the platform and ensure that the test equipment did not limit access of plant personnel to the Deister screen. During this first test, it became apparent that the hood positioning was difficult to control and that some safety problems were possible. Accordingly, Entropy abandoned this approach. On December 18, the scaffolding and carriage system was installed and tested. This approach worked well during the remainder of the tests.

Electrical supply problems occurred during the initial set-up phase of the testing at the plant. The 110 VAC outlets at the plant were not energized. On December 17, Entropy rented and installed a portable electric generator to provide 110 VAC power to the sampling train, the ambient PM10 monitors, and the weather station.

3.3 TEST RESULTS

3.3.1 Stone Moisture Content

The stone moisture levels for the Deister PM10 emission factor tests are presented in Table 3-2. The moisture criteria proposed in the Test Plan were: dry condition - less than 1.5%, and wet conditions - equal to or greater than 1.5%. These values are basically consistent with these criteria. Only test number 6 had a value outside of this range. The slightly low moisture level of 1.22% in run 6 did not have a significant impact on the PM10 emission test results.

During the emission tests, the stone color was used to qualitatively evaluate moisture levels. Short term changes in stone moisture were indicated by a shift from grey to white. These variations occurred in all of the wet condition tests, but they could not be quantified because of the time needed to obtain a representative stone sample.

TABLE 3-2. STONE MOISTURE LEVELS

Date	Conditions	Test	Moisture Content (% weight)
12-17-91	Dry	1	0.21
12-19-91	Dry	2	0.61
12-19-91	Dry	3	0.61
		Average	0.48
12-20-91	Wet	4	1.96
01-02-92	Wet	5	1.52
01-06-92	Wet	6	1.22
		Average	1.57

Stone moisture levels were controlled by the plant personnel operating certain water spray headers in the process. During the wet condition tests, the spray nozzles on the outlet of the tertiary crusher (stream 10, Figure 2-1) and the spray header on the conveyor No. 5 transfer point were used. The water spray from the transfer point header was not uniformly distributed across the stone layer. The main pipe leading to the nozzles at this point had cracked during recent cold weather and all of the water flow was coming from the crack instead of the spray nozzles. Accordingly, there was a side-to-side nonuniformity in the stone moisture levels on the conveyor approaching the Deister screens. This variation is not addressed in the average values presented in Table 3-2.

Moisture content is a strong function of the stone size distribution. Essentially all of the moisture present in a given stone sample is present in the small size ranges having high surface areas. This is indicated in Table 3-3 concerning the moisture levels in selected size ranges for a sample taken during test run 6.

TABLE 3-3. MOISTURE CONTENT OF SIZE FRACTIONS (DECEMBER 19, 1991 SAMPLE)

Size	Percent Moisture
> 1.5 inches	0.0
> 0.75 inches	0.05
No. 4	0.22
No. 20	1.4
No. 100	4.3
No. 200	8.4
Pan	7.2
Weighted Average	0.524

3.3.2 Wind Speed and Condition

Ambient wind speed and direction are two of the variables influencing the PM10 emission rates. As part of the Test Plan, Entropy established the following basic criteria applicable to the wind conditions:

- Wind speeds should be less than 15 mph
- Winds should not be from the east

The wind direction is important since the Deister screen was tested only 7 feet to the west of a Deister screen operating in parallel. A easterly air flow could cause higher-than-actual PM10 emission data. The 15 mph limit was proposed since higher winds are not typical of this geographical area.

The wind speed and directional data obtained from the meteorological station above the Deister screen are presented in Table 3-4. The conditions were generally well within the Test Plan criteria. There were some short term wind gusts above 15 mph on December 19; however, the average velocity was well below 15 mph during each hour of testing. On January 6, 1992, there were some short term periods of easterly wind; however, the hourly average values were from the east during only one of the 6 hours of this test run. Entropy concluded that the weather conditions satisfied the Test Plan criteria.

TABLE 3-4.

WIND SPEED AND DIRECTION,
TERTIARY CRUSHER ENCLOSURE TESTS

Date	Time	Wind Direction	Hourly[1] Average Wind Speed	Peak Wind
12-17-91	14:20	NW	9.5	15.5
	14:33[2]	W	9.3	14.2
12-19-91	13:20	NW	10.0	17.7
	14:20	W	9.6	17.1
	15:20	NW	7.5	13.1
	15:32[2]	SW	7.6	12.6
12-20-91	11:40	WNW	0.1	0.4
	12:40	NW	0.1	0.4
	13:28[2]	N	0.7	2.6
01-02	09:48	S	0.7	3.8
	10:48	S	1.1	3.8
	11:48	S	1.1	4.3
	12:48	W	1.5	4.3
	13:48	NNW	2.4	5.9
	14:48	SW	2.7	5.8
	15:34[2]	S	1.8	5.0
01-06-92	09:12	S	0.7	2.6
	10:12	S	0.8	3.4
	11:12	S	2.6	6.8
	12:12	S	0.9	3.1
	13:12	WSW	0.5	3.8
	14:12	N	1.4	6.7
	15:12	NE	3.2	4.6
	16:12	N	1.6	4.3
	16:37[2]	SW	0.2	1.2

Notes: 1 - Hourly averages for time period ending at time shown.
2 - Meteorological station turned off at end of test run, hour not completed.

3.3.3 Ambient PM10 Concentrations

The ambient PM10 concentrations were monitored by means of a set of two Anderson PM10 Hi-Vol samplers. These instruments have a cyclonic pre-collector for particles greater than 10 microns followed by a back-up filter. The analyzers were located on the southwest corner of the Deister platform. In this location, they indicated the PM10 levels in the air entering the Deister and entraining particulate from the screens.

These analyzers were turned on immediately prior to the emission test and turned off at the conclusion of the test. The PM10 concentrations were calculated by dividing the filter catch weights by the total standard cubic feet sampled during the on-line time.

The ambient PM10 levels presented in Table 3-5 are relatively high. This is due to (1) the heavy airplane traffic through near-by Raleigh-Durham airport, (2) an adjacent asphalt plant, and (3) vehicle traffic on a major highway (U.S. Route 70) approximately 0.5 miles from the Deister platform.

TABLE 3-5.
AMBIENT PARTICULATE CONCENTRATION
STANDARD GAS CONDITIONS

	Time		HiVol#1		HiVol#2	
	Start	Stop	$\mu g/ft^3$	$\mu g/M^3$	$\mu g/ft^3$	$\mu g/M^3$
12-17-91	12:30	15:00	16.5	582	25.9	914
12-19-91	11:57	15:35	12.6	445	N.D.[1]	-
12-20-91	10:20	14:00	17.6	621	14.9	526
01-02-92	08:55	15:45	7.1	251	23.1	816
01-06-92	08:05	14:35	N.D.[2]	-	36.7	1296

Notes: 1 - Filter damaged during weighing
2 - HiVol not available

3.3.4 Stone Production Rates

The Deister (west unit) stone processing rates were calculated based primarily on the data provided by the plant's weigh belt scale (stream 3, Figure 2-1). The total stone production rate through the Deister screens-tertiary crusher circuit was divided in half based on the assumption that both Deister screens received equal stone loadings. The total processing rate during the test was calculated by multiplying the average stone production rate times the duration of the emission data. The hour-by-hour production rate data and the calculated stone production rates during the tests are presented in Table 3-6.

TABLE 3-6. STONE PRODUCTION DATA

Date	Test	Condition	West Deister Processing Rate, Tons
12-17-92	1	Dry	243
12-19-92	2	Dry	214
12-19-92	3	Dry	218
12-20-91	4	Wet	672
01-02-92	5	Wet	1,254
01-06-92	6	Wet	1,467

3.3.5 PM10 Emission Factors

The PM10 emission factors were calculated in accordance with the procedures illustrated in the example calculation of Appendix B. The particulate captured on the filter, in the cyclone outlet tube, and in the filter inlet housing was weighed and added to yield a total capture weight. This value is divided by the standard cubic feet of gas sampled to determine the concentration of PM10 particulate matter in the gas sampled. This concentration was reduced by the amount equivalent to the ambient PM10 emissions. This adjustment was necessary since the air responsible for entraining the PM10 particles on the Deister screen entered with a moderate concentration of PM10 material due to other sources. This adjustment was approximately 5 to 30% of the observed PM10 concentration.

The total PM10 emissions were determined by multiplying the constant gas flow rate (standard conditions) of the hood-fan system times the 28 separate sampling locations. The total gas flow rate from the Deister screen was multiplied by the measured PM10 concentration to yield the total PM10 emission rate.

The data are expressed in pounds of PM10 per ton of stone processed through the west Deister screen. The production rate was estimated using the weigh belt scale and averaging the data for the period of the emission test. It was assumed that both of the Deister screens receive an equal stone loading. It should be noted that the stone load-ing calculated in this manner is lower than the actual stone quantities moving through the Deister screens. These values do not reflect the recirculation of oversized material to the tertiary crusher and back up to the Deister screens. The quantity of recycled oversize material is very difficult to monitor.

The measured PM10 emission factors are presented in Table 3-7. The average values for the wet tests are approximately a factor of 10 below the average value for the dry tests. This is consistent with general observations during the emission tests. During the dry tests, there were slight visible emissions from the Deister screen. No visible emissions were apparent during the wet tests. The extremely low emissions occurring during the wet tests are indicated the photograph shown in Figure 3-1 which was taken during the January 6, 1992 wet condition test.

The emission factors measured during the emission test program are well below previously reported emission factors for total particulate matter[9]. This difference is reasonable since stone crushing processes can generate high concentrations of large diameter particulate when the stone is very dry or the ambient wind speed is very high. The earlier tests were mainly conducted on sources with baghouses for control. Therefore, wet suppression was not used to minimize emissions and the stone was probably very dry (data not provided). The Entropy test crew observed that the visible emissions dropped to negligible levels when the wet suppression equipment was turned on at the Raleigh-Durham plant.

The emission factors applicable to total emissions cannot be compared with the PM10 emission factors. The PM10 fraction of the total particulate emissions should be relatively low since very high energy levels are needed to cause stone attrition to the 10 micron range. It is unlikely that the tertiary crusher and Deister screens were creating substantial quantities of PM10 particulate.

TABLE 3-7. DEISTER SCREEN PM10 EMISSIONS

	PM10 Emissions; Pounds/Ton
Dry Stone (< 1.5%)	
Run 1	0.00175
Run 2	0.01291
Run 3	0.00389
Average	0.00618
Wet Stone (> 1.5%)	
Run 4	0.00065
Run 5	0.00049
Run 6	0.00050
Average	0.00054

Note: All emissions have been adjusted for ambient levels.

Figure 3-1. Conditions During January 6th (Wet Condition Test)

The small quantities of fine stone particles is further indicated by the particle size distribution data. Stone samples from conveyor No. 5 (stream 3 of Figure 2-1) were analyzed using a set of ASTM screens. After the initial sizing procedure, the stone samples were dried on the ASTM screens, reshaken, and reweighed. The dry weights provide an indication of the total quantity of fine particulate matter present in the stone samples.

TABLE 3-8. PARTICLE SIZE DISTRIBUTIONS

Size Range	Fraction of Sample in Specified Range			
	Test 2, Wet		Test 3, Wet	
	As Sampled	Dried	As Sampled	Dried
> 1.5 Inches	0	0	0	0
> 0.75 Inches to 1.5 Inches	0.355	0.364	0.122	0.110
> No. 4 mesh to 0.75 Inches	0.467	0.450	0.496	0.503
> No. 20 mesh to No. 4 mesh	0.130	0.109	0.250	0.234
> No. 100 mesh to No. 20 mesh	0.047	0.039	0.129	0.086
> No. 200 mesh to No. 100 mesh	0.00026	0.01220	0	0.0254
< No. 200 mesh	0	0.02587	0	0.0410

As indicated in Table 3-8, the wet test conditions involved stone having near negligible levels of dust in the less than 100 mesh size range. Particles which do not pass through a 100 mesh screen are approximately 140 microns.

Following drying on the ASTM sizing screens, substantially larger of less than 100 mesh and less than 200 mesh particle quantities were found. However, even in the extreme conditions of bone dry stone and severe shaking, the fraction of stone in the less than 200 mesh (< 70 microns) range is relatively small. The fraction of stone in the less than 10 micron range during "as sampled" conditions must be extremely small based on the stone sizing data.

3.3.6 Stone Metals Content

Several of the dried and reshaken stone samples were analyzed for metals content. The material analyzed consisted of the minus 200 mesh solids. Results are provided in Table 3-9.

TABLE 3-9. STONE METALS CONTENT

Date	Test Condition	Metals Content, $\mu g/g$ Cd	Ni	Pb	Pounds/Ton Cd	Ni	Pb
12-19-91	Dry	<3.85	19.2	30.6	1.9×10^{-8}	9.6×10^{-8}	15.3×10^{-8}
01-06-92	Wet	<2.25	35.1	27.8	1.1×10^{-8}	17.6×10^{-8}	13.9×10^{-8}

4.0 QA/QC ACTIVITIES

4.1 QC PROCEDURES

The specific internal quality assurance and quality control procedures used during this test program are described in this section. Section 4.2 presents the field blank collection procedures. Velocity and volumetric flow rate data collection are discussed in Section 4.3. Section 4.4 discusses QA audits. QC procedures for particulate and percent isokinetics are presented in Sections 4.5 and 4.6, respectively. Manual equipment calibration is described in Section 4.7. Data validation is discussed in Section 4.8.

4.2 FIELD BLANK

Background levels of PM10 attributable to the sampling system were determined by conducting a blank run. This was performed at the Deister screen location at the Raleigh-Durham facility. Except for the elimination of the track mounted hood, procedures followed those outlined in Section 2.3.2. All applicable sampling equipment checks and procedures recommended by Method 201-A were performed. The results of the blank run indicated that no solids accumulated in the duct, which contributes to reentrainment of PM10 particles or generation of PM10 particles. The field blank run produced PM10 concentrations similar to the ambient PM10 levels monitored the same day.

4.3 VELOCITY/VOLUMETRIC FLOW RATE DETERMINATION

The QC procedures for velocity/volumetric flow rate determinations follow guidelines set forth by EPA Method 2.

Flue gas moisture was determined according to EPA Method 4 sampling trains. Flue gas moisture content (B_{ws}) was determined by dividing the volume (mass) of moisture collected by the impingers by the standardized volume of gas sampled. The following QC procedures were followed in determining the volume of moisture collected:

- Preliminary reagent tare weights were measured to the nearest 0.1 g.
- The balance zero was checked and re-zeroed as necessary before each weighing.
- The balance was leveled and placed in a clean, motionless environment for weighing.
- The indicating silica gel was fresh for each run.
- The silica gel impinger gas temperature was maintained below 68°F.

The QC procedures below were followed regarding accurate sample gas volume determination:

- The dry gas meter is fully calibrated every 6 months using an EPA approved intermediate standard.

- The gas meter was read to a thousandth of a cubic foot for the initial and final readings.

- The meter thermocouples were compared with ambient prior to the test run as a check on operation.

- Readings of the dry gas meter, meter orifice pressure (ΔH), and meter temperatures were taken at every sampling point.

- Accurate barometric pressures were recorded at least once per day.

- Post-test dry gas meter checks were completed to verify the accuracy of the meter full calibration constant (Y).

- The S-type pitot tube was visually inspected before sampling.

- Both legs of the pitot tube were leak checked before and after sampling.

- Proper orientation of the S-type pitot tube was maintained while making measurements. The roll and pitch axis of the S-type pitot tube were maintained at 90° to the flow.

- The pitot tube/manometer umbilical lines were inspected before and after sampling for moisture condensate.

- Cyclonic or turbulent flow checks were performed prior to testing the source.

- An average velocity pressure reading were recorded at each point instead of recording extreme high or low values.

- Pitot tube coefficients were determined based on physical measurement techniques as delineated in Method 2.

- The stack gas temperature measuring system was checked by observing ambient temperatures prior to placement in the stack.

4.4 QA AUDITS

Meterbox calibration audits were performed according to Method 5, section 4.4. All of the equipment pre-test and post-test results are presented in Table 4-1.

4.5 PARTICULATE/CONDENSIBLES SAMPLING QC PROCEDURES

Quality control procedures for particulate sampling ensure high quality flue gas concentrations and emissions data. Flue gas concentrations are determined by dividing the mass of analyte (particulate) collected by the standardized volume of gas sampled. Sampling QC procedures which ensure that a representative amount of the analytes are collected by the sampling system include:

- The sampling rate is within 20 percent of isokinetic (100 percent).
- The probe and filter temperatures are maintained at >50°F ambient.
- Only properly prepared glassware is used.
- All sampling nozzles were be manufactured and calibrated according to EPA standards.
- Filters are weighed, handled, and stored in a manner to prevent any contamination.
- Recovery procedures are completed in a clean environment.
- Field reagent blanks are collected.

4.6 SAMPLE VOLUME AND PERCENT ISOKINETICS

All sampling runs met the results acceptability criteria as defined by Section 6.3.5 of Method 201-A. The isokinetic rates are within ±20 percent. A summary of the sample volume and percent isokinetics is presented in Table 4-1.

TABLE 4-1.

DEISTER TEST AVERAGE DELTA H AND ISOKINETIC RESULTS

Run No.	Percent Isokinetic	ΔH (Avg)
12-17-91, Test 1	90.7	.617
12-19-91, Test 2	83.0	.588
12-19-91, Test 3	83.9	.588
12-20-91, Test 4	87.6	.627
01-02-92, Test 5	88.3	.700
01-06-92, Test 6	92.8	.738

4.7 MANUAL SAMPLING EQUIPMENT CALIBRATION PROCEDURES

4.7.1 Type-S Pitot Tube Calibration

The EPA has specified guidelines concerning the construction and geometry of an acceptable Type-S pitot tube. If the specified design and construction guidelines are met, a pitot tube coefficient of 0.84 is used. Information pertaining to the design and construction of the Type-S pitot tube is presented in detail in Section 3.1.1 of EPA Document 600/4-77-027b. Only Type-S pitot tubes meeting the required EPA specifications are used. Pitot tubes are inspected and documented as meeting EPA specifications prior to field sampling.

4.7.2 Sampling Nozzle Calibration

Calculation of the isokinetic sampling rate requires that the cross sectional area of the sampling nozzle be accurately determined. All nozzles are thoroughly cleaned, visually inspected, and calibrated according to the procedure outlined in Section 3.4.2 of EPA Document 600/4-77-027b.

4.7.3 Temperature Measuring Device Calibration

Accurate temperature measurements are required during source sampling. Bimetallic stem thermometers and thermocouple temperature sensors are calibrated using the procedure described in Section 3.4.2 of EPA Document 600/4-77-027b. Each temperature sensor is calibrated at a minimum of three points over the anticipated range of use against a NIST-traceable mercury-in-glass thermometer. All sensors are calibrated prior to field sampling.

4.7.4 Dry Gas Meter Calibration

Dry gas meters (DGM's) are used in the sample trains to monitor the sampling rate and measure the sample volume. All DGM's are fully calibrated to determine the volume correction factor prior to their use in the field. Post-test calibration checks are performed as soon as possible after the equipment has been returned as a QA check on the calibration coefficients. Pre- and post-test calibrations should agree within 5 percent. The calibration procedure is documented in Section 3.3.2 of EPA Document 600/4-77-237b.

Prior to calibration, a positive pressure leak check of the system is performed using the procedure outlined in Section 3.3.2 of EPA Document 600/4-77-237b. The system is placed under approximately 10 inches of water pressure and a gauge oil manometer is used to determine if a pressure decrease can be detected over a one-minute period. If leaks are detected, they are eliminated before actual calibrations are performed.

After the sampling console is assembled and leak checked, the pump is allowed to run for 15 minutes to allow the pump and DGM to warm-up. The valve is then adjusted to obtain the desired flow rate. For the pre-test calibrations, data are collected at orifice manometer settings (ΔH) of 0.5, 1.0, 1.5, 2.0, 3.0 and 4.0 inches H_2O. Gas volumes of 5 ft^3 are used for the two lower orifice settings, and volumes of 10 ft^3 are used for the higher settings. The individual gas meter correction factors (Y_i) are calculated for each orifice setting and averaged. The method requires that each of the individual correction factors fall within ± 2 percent of the average correction factor or the meter is cleaned, adjusted, and recalibrated. For the post-test calibration, the meter is calibrated three times at the average orifice setting and vacuum used during the actual test. The meter box calibration data is presented in Table 4-2.

Table 4-2. Meter Box Calibration Audit

Meter Box Number	Pre-Audit Value	Allowable Error	Calculated Gamma	Acceptable
N-6	0.9871	0.9476<Y<1.0265	1.0128	Yes
N-14	0.9948	0.9550<Y<1.0346	0.9707	Yes

4.8 DATA VALIDATION

All data and/or calculations for flow rates, moisture content, and isokinetic rates made using a computer software program are validated by an independent check. All calculations are spot checked for accuracy and completeness.

In general, all measurement data are validated based on the following criteria:

- Process conditions during sampling or testing.
- Acceptable sample collection procedures.
- Consistency with expected other results.
- Adherence to prescribed QC procedures.

5.0 REFERENCES

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9. JACA Corporation, Control of Air Emissions from Process Operations in the Rock Crushing Industry," EPA Contract No. 68-01-4135, U.S. Environmental Protection Agency, Washington, D.C., February 1978.

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6.0 GLOSSARY

1. ASTM: American Society for Testing & Materials

2. Aggregate: in the case of materials of construction, essentially inert materials which, when bound together into a conglomerated mass by a matrix, form concrete, mastic, mortar or plaster; crushed rock or gravel screened to size for use in road surfaces, concrete or bituminous mixes; any of several hard materials such as sand, gravel, stone, slag, cinders or other inert materials used for mixing with a cementing material to form concrete. Aggregate, in a surface course in the building of roads is often called a "road metal".

3. Conveyor belt: a rubberized belt, usally 18" to 60" wide, used to carry aggregates.

4. Crusher (cone): a crusher that is specially designed to produce fines.

5. Crusher (primary): usally a jaw or gyratory type crusher which reduces very large rocks to a size that can be processed by a secondary crusher.

6. Crusher (secondary): any second or third stage crusher that further reduces the size of stone.

7. Fines: the smaller particles of aggregates; usually less than .25" in size.

8. Head Pulley: the driving pulley, usually at the discharge end of conveyor belt.

9. Ro-Tap screen: trade name for a type of testing screen.

10. Scalping: a screening operation, removing stone too large for the crusher.

11. Scalping Screen: removes oversize material.

12. Screen (or sieve): a metallic plate or sheet, woven wire cloth or similiar device, with regularly spaced apertures of uniform size mounted in a suitable frame or holder for use in separating material according to size.

APPENDIX A.

Results in Table Form

Table A-1, Stone Production Rates

Date	Time[1]	Primary Rates[2] (T/Hr.)	West Deister Screen Feed (T/Hr.)
12-17-92	13:20	560	240
	13;30	590	255
	13:45	630	275
	14:00	620	270
	14:15	600	260
	14:30	600	260
		Average =	260
		Test Time =	56 Minutes
		Production Total =	243 Tons
12-19-92	12:20	520	220
	12:30	Down	Down
	12:45	Down	Down
	13:00	550	235
	13:15	530	225
	13:30	570	245
	13:45	520	220
		Average =	229 Tons/Hour
		Test Time =	56 Minutes
		Production Total =	214 Tons
12-19-92	14:00	530	225
	14:15	530	225
	14:30	560	240
	14:45	560	240
	15:00	Down	Down
	15:15	560	240
		Average =	234 Tons/Hour
		Test Time =	56 Minutes
		Production Total =	218 Tons

Table A-1, Stone Production Rates

Date	Time[1]	Primary Rates[2] (T/Hr.)	West Deister Screen Feed (T/Hr.)
12-20-91	10:45	540	230
	11:00	550	235
	11:15	520	220
	11:30	560	240
	11:45	480	200
	12:00	510	215
	12:15	600	260
	12:30	580	250
	12:45	610	265
	13:00	580	250
	13:15	580	250
	13:30	600	260
			Average = 240
			Test Time = 168 Minutes
			Production Total = 671 Tons
01-02-92	08:45	570	245
	09:45	550	225
	10:00	560	240
	10:15	550	235
	10:30	540	230
	10:45	520	220
	11:00	550	235
	11:15	570	245
	11:30	580	250
	11:45	580	250
	12:00	570	245
	12:15	560	225
	12:30	550	235
	12:45	550	235
	13:00	560	240
	13:15	Down	Down
	13:30	Down	Down
	13:45	Down	Down
	14:00	Down	Down
	14:15	580	250
	14:30	Down	Down
	14:45	580	250
	15:00	600	260
	15:15	550	235
			Average = 224 Tons
			Test Time = 336 Minutes
			Production Total = 1254 Tons

Table A-1, Stone Production Rates

Date	Time[1]	Primary Rates[2] (T/Hr.)	West Deister Screen Feed (T/Hr.)
01-06-92	08:00	600	260
	08:15	620	270
	08:30	590	255
	08:45	600	260
	09:00	580	250
	09:15	Down	Down
	09:30	Down	Down
	09:45	Down	Down
	10:00	Down	Down
	10:15	580	250
	10:30	Down	Down
	10:45	520	220
	11:00	560	240
	11:15	580	250
	11:30	570	245
	11:45	580	250
	12:00	600	260
	12:15	620	270
	12:30	600	260
	12:45	610	265
	13:00	620	270
	13:15	620	270
	13:30	620	270
	13:45	640	280
	14:00	660	290
	14:15	660	290
	14:30	660	290

Average = 272 Tons
Test Time = 336 Minutes
Production Total = 1467 Tons

RALEIGH RUN DATA

DATE	TEST NO.	TEST CONDITION	Q_{S-A} (ACF)	T_S (°R)	T_{STK} (°R)	P_{BS} (INCHES Hg)	P_B (INCHES Hg)	X (%)	T_{TEST} (°R)
12-17-91	1	DRY	30.736	528	524	29.92	29.8	1.0	560
12-19-91	2	DRY	26.850	528	500	29.92	30.3	1.0	562
12-19-91	3	DRY	27.018	528	501	29.92	30.3	1.3	561
12-20-91	4	WET	85.314	528	508	29.92	30.3	1.6	574
1-2-92	5	WET	170.000	528	511	29.92	30.2	0.3	561
1-6-92	6	WET	170.258	528	513	29.92	29.7	1.4	543

DATE	TEST NO.	TEST CONDITION	RIGHT MONITOR W_{AMB-R} (MG)	RIGHT MONITOR $Q_{AMB-STD}$ (SCF)	RIGHT MONITOR $C_{PM10-AMB}$ (MG/SCF)	LEFT MONITOR W_{AMB-L} (MG)	LEFT MONITOR $Q_{AMB-STD}$ (SCF)	LEFT MONITOR $C_{PM10-AMB}$ (MG/SCF)
12-17-91	1	DRY	52.1	3145	0.0165	71.1	2739	0.0259
12-19-91	2	DRY	59.6	4722	0.0126	N.D.	4120	-
12-19-91	3	DRY	-	-	-	-	-	-
12-20-91	4	WET	81.0	4593	0.0176	57.8	3883	0.0149
1-2-92	5	WET	64.3	9017	0.0071	176.0	7611	0.0231
1-6-92	6	WET	N.D.	-	-	256.8	6998	0.0367

RALEIGH RUN DATA

DATE	TEST NO.	TEST CONDITION	W_F (MG)	Q_{S-STD} (SCF_{DRY})	C_{PM10}	$*C_{PM10AMB}$ (MG/SCF_{DRY})	$C_{PM10AMB}A$
12-17-91	1	DRY	7.0	28.58	0.245	0.0212	0.2238
12-19-91	2	DRY	35.4	25.29	1.40	0.0126	1.387
12-19-91	3	DRY	11.2	25.42	0.441	0.0126	0.4282
12-20-91	4	WET	7.0	78.20	0.090	0.0163	0.0737
1-2-92	5	WET	11.5	161.01	0.071	0.0151	0.0559
1-6-92	6	WET	16.2	162.04	0.100	0.0367	0.0633

DATE	TEST NO.	TEST CONDITION	T_{TEST} (MIN)	Q_{F-A} (ACF/MIN)	Q_{F-STD} (SCF)	E_{PM10} (POUNDS)	P_D (TONS)	E_f (LBS/TON)
12-17-91	1	DRY	56	640.6	997,988	0.491	280	0.00175
12-19-91	2	DRY	56	640.6	1,063,440	3.24	251	0.01291
12-19-91	3	DRY	56	640.6	1,054,886	0.995	256	0.00389
12-20-91	4	WET	168	640.6	3,121,049	0.507	783	0.00065
1-2-92	5	WET	336	640.6	6,266,683	0.772	1572	0.00049
1-6-92	6	WET	336	640.6	6,071,172	0.846	1691	0.00050

APPENDIX B.

Example Calculations

Example Calculation of PM10 Emission Factors

Variables

Q_{S-A}	=	Actual gas sampled by M201A train; ACF
Q_{S-STD}	=	Gas sampled by M210A train; SCF_{Dry}
Q_{F-A}	=	Gas flow rate through hood and fan; ACF/Min
Q_{F-STD}	=	Gas flow rate through hood and fan; SCF_{Dry}/Min
Q_{AMB-A}	=	Gas flow rate through ambient PM10 monitor; ACF/Min
$Q_{AMB-STD}$	=	Gas flow rate through ambient PM10 monitor; SCF_{Dry}/Min
T_s	=	Standard temperature, 528 Degrees °R
T_T	=	Meter box gas temperature, (460°R + x °F)
T_{STK}	=	Stack Temperature, (460 °R + x °F)
P_B	=	Barometric pressure during test, inches Hg.
P_{BS}	=	Standard Atmospheric Pressure, 29.92 inches Hg.
W_F	=	Total PM10 catch weight in M201A train, mg
W_{AMB}	=	Total PM10 catch weight in M201A ambient sampler, mg
X	=	Moisture in flue gas, %(volume)

1. Calculation of gas volume (standard) sampled in M201A;

$$Q_{S-STD} = (Q_{S-A})(T_s/T_T)(P_B/P_{BS})((1-X)/1)$$

2. Concentration of PM10 in gas sampled; C_{PM10}

$$C_{PM10} = (W_F/Q_{S-STD})$$

3. Calculation of gas volume(standard) sampled in ambient sampler;

$$Q_{AMB-STD} = (Q_{AMB-A})(0.33FT^2)(T_S/T_{STK})(P_B/P_{BS})(T_{TEST})((1-X)/1)$$

4. Calculation of ambient PM10 concentration

$$C_{PM10AMB} = W_{AMB}/Q_{AMB-STD}$$

5. Calculation of average ambient PM10 concentration

$$*C_{PM10AMB} = (C_{PM10AMB\ Left} + C_{PM10AMB\ Right})/2$$

6. Calculation of adjusted PM10 concentration in M201A gas sampled

$$C_{PM10AMB}A = (C_{PM10} - *C_{PM10AMB})$$

7. Calculation of total gas flow rate from deister

$$Q_{F-STD} = (Q_{F-A})(28\ \text{Sample Points})(T_S/T_{STK})(P_B/P_{BS})(T_{TEST})((1-X)/1)$$

8. Calculation of total PM10 emissions

$$E_{PM10} = (C_{PM10AMB}A)(Q_{F-STD})(\text{Grams}/1000)(\text{Pounds}/454\text{Grams})$$

9. Calculation of Deister processing rate

P_D = Deister Rate = (P/2)

10. Calculation of PM10 Emission factors

$E_f = (E_{PM10}/P_D)$

Example Calculation.

Test 1 Dry
Dec 17, 1991

1.) $Q_{S-STD} = (30.736\ ACF)\left(\frac{528°R}{560°R}\right)(29.8''/29.92'')(0.99) = 28.57\ SCF_{DRY}$

2.) $C_{pm10} = \frac{7.0\ mG}{28.57\ SCF_{DRY}} = 0.245\ Mg/SCF_{DRY}$

3.) $\underset{(Right)}{Q_{AMB-STD}} = (62\ FT/min)(.33\ Ft^2)\left(\frac{528°R}{508°R}\right)\left(\frac{29.8''}{29.92''}\right)(0.99)(150\ Min) = 3145\ SCF_{DRY}$

$\underset{(LEFT)}{Q_{AMB-STD}} = (54\ FT/MIN)(.33\ FT^2)\left(\frac{528°R}{508°R}\right)\left(\frac{29.8''}{29.92''}\right)(0.99)(150\ Min) = 2739\ SCF_{DRY}$

4.)

$\underset{(Right)}{C_{pm10-AMB}} = \frac{52\ mg}{3145\ SCF_{DRY}} = 0.0165\ MG/SCF_{DRY}$ (Right)

$\underset{(Left)}{C_{pm10-AMB}} = \frac{71\ mg}{2739\ SCF_{DRY}} = 0.0259\ MG/SCF_{DRY}$ (Left)

5.) $*C_{pm10-AMB} = \left(\frac{0.0165\ MG}{SCF_{DRY}} + \frac{0.0259\ MG}{SCF\ DRY}\right)/2 = 0.0212\ mg/SCF_{DRY}$

6.) $C_{pm10AMB}\ A = \frac{0.245\ MG}{SCF\ DRY} - \frac{0.0212\ MG}{SCF_{DRY}} = 0.2238\ MG/SCF_{DRY}$

7.) $Q_{F-STD} = \left(640.6\ \frac{ACF}{\frac{MIN}{PT}}\right)(28\ POINTS)\left(\frac{528°R}{524°R}\right)\left(\frac{29.8''}{29.92''}\right)(.99)(56\ min)$

$= 997{,}988\ SCF_{DRY}$

Job Number

Job Name

Subject

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Research Triangle Park, NC 27709-2291
1-800-486-3550

CALCULATION SHEET

8.) $E_{PM10} = \left(\frac{0.2238 \text{ MG}}{\text{SCF DRY}}\right)(997{,}988 \text{ SCF}_{DRY})\left(\frac{\text{Grams}}{1000 \text{ MG}}\right)\left(\frac{\text{Pounds}}{454}\right)$

$= 0.491$ Pounds

9.)

560 Primary Rates in
590 Tons/Hr (See Appendix A)
630
620
600
600
3600 avg 600 Tons/Hr

P_D = Deister Rate = $\frac{600 \text{ Tons/Hr}}{2} = 300 \frac{\text{TONS}}{\text{Hr}}$

10.) $E_f = \frac{0.491 \text{ Pounds}}{\left(300 \text{ TONS/Hr} \; \frac{\text{Hr}}{60\text{min}} \; \frac{56\text{min}}{1}\right)} = \frac{.00175 \text{ Pounds}}{\text{Ton}}$

Job Number
Job Name
Subject
Version
Sheet of
Prepared By
Date
Checked By
Date

ENTROPY

ENVIRONMENTALISTS INC.
Research Triangle Park, NC 27709-2291
1-800-486-3550

CALCULATION SHEET

APPENDIX C.

Raw Field Data and Calibration Data Sheets

PRELIMINARY VELOCITY AND CYCLONIC FLOW DETERMINATIONS

Plant Name: Martin Marietta — Job No.: 2684

City/State: Raleigh NC — Date: 12-17-91

Test Location: #R DEISTER SCREEN — Personnel: TTB, HWL

Barometric Pres. (Pbar): 29.9 In. Hg — Static Pres. (Pg): -.2867 In. H_2O

Pitot ID: 4H-72-2 — Pitot Coeff. (Cp): .84 — Pressure Gauge Set ID: ADM-960

Thermocouple ID: ADM-960 — Duct Length/Diameter: 10'/1' — Width:

--Specify inches (") or feet (')--

TRAVERSES
Start-Finish Times: ____ - ____

Pt. No.	Yaw ∡°	ΔP "H_2O	Temp °F
1		.0777	63
2		.0551	↓
3		.0593	↓
4		.0476	↓
Avg*		.0544	

ORSAT DATA

Sampling Time	Analysis Time	CO_2 (A) Reading	O_2 (B) Reading	%O_2 (B-A)	%CO+N_2 (100-B)
	Average				

Bag No. ________ Pump ________

FYRITE DATA, % CO_2				

MOISTURE DATA (WET BULB/DRY BULB)

Port	Time	Dry Bulb °F	Wet Bulb °F	Diff.	% H_2O

MOISTURE DATA (STOICHIOMETRIC)

Free Water in Fuel, %	
Water from Fuel Combustion, %	
Ambient Water, %	
Relative Humidity, %	
Ambient Temperature, °F	
Total %	

VOLUMETRIC AIR FLOW RATES

Dry at Standard Conditions, Qsd =	SCFM
Wet at Stack Conditions, Qaw =	ACFM

HORIZONTAL DUCT FLYASH/DUST BUILDUP >1" DEPTH?

Yes__ No__ If yes, see page 2 for instructions

* 1. ∡ average is summation of absolute values divided by number of measurements and must be ≤ 20°.
2. ΔP average is square of average square root.

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See page 2 for cyclonic flow check criteria.

ENTROPY

FIELD DATA - METHOD(S) ______

PLANT Martin Marietta RUN NO. SR-DRY-1-12-17
CITY/STATE Raleigh, NC JOB NO. 7264 DATE 12-17-91
SAMPLING LOC. Dester Screen TIME START 1330
BAROMETRIC PRESSURE, IN. HG 29.8 STATIC PRESSURE, IN. H2O -.867 TIME FINISH 1433
LEAK CHECK, VACUUM IN. HG 15 OPERATOR TB
LEAK RATE, CUBIC FEET/MIN. .004 ASST(S) HWL, WKK

EQUIPMENT CHECKS*	
✓	PITOT, PRETEST
✓	PITOT, POSTTEST
✓	NOZZLE, PRE/POST
✓	TC 50 °F PRE
✓	TC 64 °F POST
	ORSAT SYSTEM

FILTER/XAD	TARE WT.
2MV34	.2726

EQUIPMENT I.D. NUMBERS

REAGENT BOX 05914 METER BOX N-6 Y .9871
PITOT N/A Cp .84 NOZ'L .12Des DIA. .243
TC READOUT R-39 TC PROBE R299, 302 UMBILICAL -
SAMPL'G BOX N/A ORSAT PUMP N/A TEDLAR BAG N/A

NOMOGRAPH DATA

DELTA H@	1.779
METER TEMP	80
EST. %H2O	1
C FACTOR	1.028
STACK TEMP	50
REF DELTA P	.120
K FACTOR	15.367

LEAK CHECKS

B N/A

FYRITES

N/A

* PITOT: VISUAL INSPECTION/LEAK CHECK; NOZZLE: VISUAL INSPECTION; TC: AMBIENT TEMPS.; ORSAT SYSTEM: LEAK CHECK

LINE	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READING CUBIC FEET	PITOT READING IN. H2O	GAS METER TEMP. °F	STACK TEMP. °F	ORIFICE SETTING IN. H2O ACTUAL	ORIFICE SETTING IN. H2O IDEAL	GAUGE VACUUM IN. HG	GAS TEMPERATURES °F FILTER *	IMPING. EXIT	PROBE OR COND EXIT**
1	A-1	0	257.905	.0777	84	56	.67	.67	71	133		
2	1	5	260.195	.0777	92	56		.7	71	158		
3	1	10	262.495	.0777	96	60		.7	71	147		
4	2	15	264.925	.051	98	63		.65	71	148		
5	2	20	267.361	.051	100	67		.7	71	141		
6	2	25	269.819	.051	102	65		.75	71	141		
7	3	30	272.280	.0593	104	64		.85	71	128		
8	3	35	274.970	.0593	104	67		.85	71	122		
9	3	40	277.672	.0593	106	67		.85	71	122		
10	4	45	280.400	.0476	106	67		.85	71	122		
11	4	50	283.150	.0476	106	71		.85	71	118		
12	4	55	285.900	.0476	104	64		.85	71	113		
13		60	288.641									
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

* FILTER EXIT for NJ Method 1. FILTER BOX for all

** PROBE EXIT & ✓ (probe & filter heat off) apply to NJ Method 1. COND EXIT applies if sampling train has a cc

Min. (θ)	Vm	$(\sqrt{\Delta p})^2$	tm	ts	ΔH
60	30.736	.0594		64	

F-1112 (Page

ENTROPY

PLANT Martin Marietta RUN NO. SR-DRY-2-1249

CITY/STATE Raleigh NC JOB NO. 3684 DATE 12-19-91

SAMPLING LOC. Deister Screen TIME START 1220

BAROMETRIC PRESSURE, IN. HG 30.3 STATIC PRESSURE, IN. H2O -.3807 TIME FINISH 1347

LEAK CHECK, VACUUM IN. HG 15 OPERATOR —

LEAK RATE, CUBIC FEET/MIN. 0.0 ASST(S) SR JWK

EQUIPMENT CHECKS*	
✓	PITOT, PRETEST
	PITOT, POSTTEST
✓	NOZZLE, PRE/POST
✓	TC 40 °F PRE
	TC °F POST
	ORSAT SYSTEM

FILTER/XAD	TARE WT.
RM66	.2453

EQUIPMENT I.D. NUMBERS

REAGENT BOX	0574	METER BOX	NC	Y	.9971
PITOT		C_p .84	NOZZ	DIA.	.343
TC READOUT		TC PROBE	299303	UMBILICAL	—
SAMPL'G BOX	—	ORSAT PUMP	—	TEDLAR BAG	—

NOMOGRAPH DATA

DELTA H@	1.779
METER TEMP	90
EST. %H2O	1
C FACTOR	1.028
STACK TEMP	35
REF DELTA P	.116
K FACTOR	15.336

LEAK CHECKS

B		B	
E		E	
B		B	
E		E	
B		B	
E		E	

FYRITES

* PITOT: VISUAL INSPECTION/LEAK CHECK; NOZZLE: VISUAL INSPECTION; TC: AMBIENT TEMPS.; ORSAT SYSTEM: LEAK CHECK

1220

1234 off Pitot Down

Start 1306

LINE	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READING CUBIC FEET	PITOT READING IN. H2O	GAS METER TEMP. °F	STACK TEMP. °F	ORIFICE SETTING IN. H2O ACTUAL	ORIFICE SETTING IN. H2O IDEAL	GAUGE VACUUM IN. HG	GAS TEMPERATURES °F FILTER *	IMPING. EXIT	PROBE OR COND EXIT**
1	1	~~1220~~	290.336	.0777	100	39	.588	.588	>1	234		
2	1	7	293.57	.0777	104	35	.588	.588	>1	218		
3	2	14	296.814	.0551	104	40	.588	.588	>1	202		
4	2	21	300.175	.0551	104	40	.588	.588	>1	161		
5	3	28	303.420	.0593	102	41	.588	.588	>1	142		
6	3	35	306.642	.0593	102	39	.588	.588	>1	132		
7	4	42	310.021	.0476	103	41	.750	.588	>1	124		
8	4	49	313.600	.0476	104	39	.750	.588	>1	113		
9		56	317.136									
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

* FILTER EXIT for NJ Method 1. FILTER BOX for all other

** PROBE EXIT & ✓ (probe & filter heat off) apply to NJ Method 1. COND EXIT applies if sampling train has a condens

56	26.850	.0594		39.25	
Min. (θ)	Vm	$(\sqrt{\Delta p})^2$	tm	ts	ΔH

.588

+50 .485

-50 .728

ENTROPY

PLANT [illegible]
CITY/STATE [illegible]
SAMPLING LOC. [illegible]
BAROMETRIC PRESSURE, IN. HG [illegible]
LEAK CHECK, VACUUM IN. HG [illegible]
LEAK RATE, CUBIC FEET/MIN. [illegible]

STATIC PRESSURE, IN. H2O -.467

RUN NO. [illegible]
JOB NO. [illegible]
DATE 12-[illegible]
TIME START 1405
TIME FINISH 1517
OPERATOR [illegible]
ASST(S) JRR [illegible]

EQUIPMENT CHECKS*	
PITOT, PRETEST	
PITOT, POSTTEST	
NOZZLE, PRE/POST	
TC 41 °F PRE	
TC °F POST	
ORSAT SYSTEM	

FILTER/XAD	TARE WT.
[illegible]	2734

EQUIPMENT I.D. NUMBERS

REAGENT BOX	[illegible]	METER BOX	[illegible]	Y	.9971
PITOT		C_p .74	NOZ'L	DIA.	[illegible]
TC READOUT	[illegible]	TC PROBE	[illegible]	UMBILICAL	[illegible]
SAMPL'G BOX	[illegible]	ORSAT PUMP	[illegible]	TEDLAR BAG	[illegible]

NOMOGRAPH DATA

DELTA H@	1.79			
METER TEMP	50			
EST. %H2O				
C FACTOR	[illegible]			
STACK TEMP	35			
REF DELTA P	.116			
K FACTOR	5.536			

LEAK CHECKS

B	N/A	B	
E		E	
B		B	
E		E	
B		B	
E		E	

N/A

FYRITES

* PITOT: VISUAL INSPECTION/LEAK CHECK; NOZZLE: VISUAL INSPECTION; TC: AMBIENT TEMPS.; ORSAT SYSTEM: LEAK CHE[CK]

LINE	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READING CUBIC FEET	PITOT READING IN. H2O	GAS METER TEMP. °F	STACK TEMP. °F	ORIFICE SETTING IN. H2O ACTUAL	ORIFICE SETTING IN. H2O IDEAL	GAUGE VACUUM IN. HG	GAS TEMPERATURES °F FILTER *	IMPING. EXIT	PROBE OR COND EXIT
1	A1	0	317.103	.0777	98	41	.50	.588	21	105		
2		5	320.410	.0777	100	41	.65	.588	21	107		
3	2	24	324.010	.0551	101	42	.65	.588	21	103		
4	2	231	327.730	.0551	103	41	.65	.588	21	95		
5	3	328	331.042	.0593	103	40	.65	.588	21	96		
6	3	335	334.419	.0593	104	40	.65	.588	21	95		
7	4	442	337.376	.0476	104	42	.65	.588	21	99		
8	4	449	341.[illegible]	.0476	10[illegible]	[illegible]	.65	.588	2[illegible]	110		
9		56	344.621									
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

* FILTER EXIT for NJ Method 1. FILTER BOX for al[l ...]

** PROBE EXIT & ✓ (probe & filter heat off) apply to NJ Method 1. COND EXIT applies if sampling train has a [...]

56	27.018	.0694		41.25	
Min. (θ)	Vm	$(\sqrt{\Delta p})^2$	tm	ts	ΔH

.64

-.447

F-1112 (Pa[ge])

ENTROPY

FIELD DATA - METHOD(S) ______

PLANT Martin Marietta RUN NO. SR/WET/1/12-x
CITY/STATE Raleigh NC JOB NO. 3644 DATE 12/20/91
SAMPLING LOC. Deister Screen TIME START 1040
BAROMETRIC PRESSURE, IN. HG 30.3 STATIC PRESSURE, IN. H2O -.407 TIME FINISH 1328
LEAK CHECK, VACUUM IN. HG 15 OPERATOR JTB
LEAK RATE, CUBIC FEET/MIN. 0.00 ASST(S) JRR, WKK

EQUIPMENT CHECKS*	EQUIPMENT I.D. NUMBERS		LEAK CHECKS	
✓ PITOT, PRETEST	REAGENT BOX 609 METER BOX N-6 Y .9871		B N/A	B
PITOT, POSTTEST	PITOT — C_p .84 NOZ'L — DIA. .243		E	E
✓ NOZZLE, PRE/POST	TC READOUT F23 TC PROBE R299 305 UMBILICAL —			
✓ TC 47 °F PRE	SAMPL'G BOX — ORSAT PUMP — TEDLAR BAG —		B	B
TC ___ °F POST			E	E
N/A ORSAT SYSTEM				

NOMOGRAPH DATA

FILTER/XAD	TARE WT.	NOMOGRAPH DATA	
PM220	.273	DELTA H@	1.779
		METER TEMP	100
		EST. %H2O	2
		C FACTOR	1.049
		STACK TEMP	45
		REF DELTA P	.0594
		K FACTOR	15.831

LEAK CHECKS: B / E / B / E

FYRITES: N/A

* PITOT: VISUAL INSPECTION/LEAK CHECK; NOZZLE: VISUAL INSPECTION; TC: AMBIENT TEMPS.; ORSAT SYSTEM: LEAK CHECK

LINE	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READING CUBIC FEET	PITOT READING IN. H2O	GAS METER TEMP. °F	STACK TEMP. °F	ORIFICE SETTING IN. H2O ACTUAL	ORIFICE SETTING IN. H2O IDEAL	GAUGE VACUUM IN. HG	GAS TEMPERATURES °F FILTER *	IMPING. EXIT	PROBE OR COND EXIT**
1	A1	0	348.823	.0777	78	48	.627	.627	>1	204	36	
2	1	6	351.65	.0777	86	44	.65		>1	199	36	
3	1	12	354.52	.0777	90	42	.70		>1	191	36	
4	1	18	357.43	.0777	96	43	.70		>1	192	36	
5	1	24	360.35	.0777	99	42	.70		>1	172	36	
6	1	30	363.32	.0777	102	42	.70		>1	172	38	
7	1	36	366.26	.0777	104	43	.70		>1	165	38	
8	2	42	369.22	.0593	108	44	.70		>1	163	40	
9	2	48	372.22	.0593	110	44	.70		>1	138	40	
10	2	54	375.24	.0593	112	45	.70		>1	130	40	
11	2	60	378.28	.0593	113	44	.70		>1	122	40	
12	2	66	381.32	.0593	114	45	.70		>1	120	40	
13	2	72	384.47	.0593	114	46	.70		>1	114	40	
14	2	78	387.42	.0593	116	44	.70		>1	113	40	
15	3	84	390.48	.0593	116	44	.70		>1	116	40	
16	3	90	393.56	.0593	117	44	.70		>1	110	40	
17	3	96	396.64	.0593	118	45	.70		>1	112	40	
18	3	102	399.74	.0593	117	46	.70		>1	114	40	
19	3	108	402.85	.0593	116	48	.70		>1	113	40	
20	3	114	405.96	.0593	117	50	.70		>1	115	40	
21	3	120	409.06	.0593	119	50	.70		>1	113	40	
22	4	126	412.17	.0476	119	51	.70		>1	106	40	
23	4	132	415.31	.0476	119	52	.70		>1	103	40	
24	4	138	418.42	.0476	120	52	.70		>1	105	40	
25	4	144	421.55	.0476	120	52	.70	✓	>1	105	41	

* FILTER EXIT for NJ Method 1. FILTER BOX for all ot...

** PROBE EXIT & ✓ (probe & filter heat off) apply to NJ Method 1. COND EXIT applies if sampling train has a conde...

178	85.314	.0694		47	
Min. (θ)	Vm	$(\sqrt{\Delta p})^2$	tm	ts	ΔH

.627
+50 .519
-.. 7.2

2.966

ENTROPY

FIELD DATA (continued)

PLANT Martin Marietta RUN NO. SR-WET-2-12-29

SAMPLING LOC. Demister Screen JOB. NO. 2084

COMMENTS

LINE	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READING CUBIC FEET	PITOT READING IN. H2O	GAS METER TEMP. °F	STACK TEMP. °F	ORIFICE SETTING IN. H2O ACTUAL	ORIFICE SETTING IN. H2O IDEAL	GAUGE VACUUM IN. HG	GAS TEMPERATURES °F FILTER *	IMPING. EXIT	PROBE OR COND EXIT*
26	4	150	424.61	.0476	120	~~2~~53	.70	.627	7	104		
27	4	156	427.75	.0476	118	51	.70	↓	7	104		
28	4	162	430.98	.0476	119	52	.70	↓	7	104		
29		178.4	434.137									
30												
31												
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62												
63												
64												
65												

* FILTER EXIT for NJ Method 1. FILTER BOX for all others.
** PROBE EXIT & √ (probe & filter heat off) apply to NJ Method 1. COND EXIT applies if sampling train has a con

Min. (θ) ____ Vm ____ $(\sqrt{\Delta p})^2$ ____ tm ____ ts ____ ΔH ____

F-1112 (Page 2)

ENTROPY

FIELD DATA - METHOD(S)

PLANT Martin Marietta
CITY/STATE Raleigh NC
SAMPLING LOC. Dexter Screen
BAROMETRIC PRESSURE, IN. HG 30.2
STATIC PRESSURE, IN. H2O -.2867
LEAK CHECK, VACUUM IN. HG 15
LEAK RATE, CUBIC FEET/MIN. .00

RUN NO. SK-WET-2-1-2
JOB NO. 3684
DATE 1-2-92
TIME START 0848
TIME FINISH 1539
OPERATOR TJB
ASST(S) RR LWK

EQUIPMENT CHECKS*
N/A PITOT, PRETEST
N/A PITOT, POSTTEST
✓ NOZZLE, PRE/POST
TC ___ °F PRE
TC ___ °F POST
N/A ORSAT SYSTEM

EQUIPMENT I.D. NUMBERS
REAGENT BOX 609 METER BOX N-6 Y .9871
PITOT N/A C_p .84 NOZ'L D3 .10 DIA. .343
TC READOUT E-23 TC PROBE B219-323 UMBILICAL —
SAMPL'G BOX — ORSAT PUMP — TEDLAR BAG —

LEAK CHECKS
B N/A

FILTER/XAD	TARE WT.
PM219	.2737

NOMOGRAPH DATA
DELTA H@ 1.779
METER TEMP 100
EST. %H2O 2
C FACTOR 1.049
STACK TEMP 45
REF DELTA P .116
K FACTOR 1.5831

FYRITES
N/A

* PITOT: VISUAL INSPECTION/LEAK CHECK; NOZZLE: VISUAL INSPECTION; TC: AMBIENT TEMPS.; ORSAT SYSTEM: LEAK CHECK

LINE	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READING CUBIC FEET	PITOT READING IN. H2O	GAS METER TEMP. °F	STACK TEMP. °F	ORIFICE SETTING IN. H2O ACTUAL	ORIFICE SETTING IN. H2O IDEAL	GAUGE VACUUM IN. HG	GAS TEMPERATURES °F FILTER *	IMPING. EXIT	PROBE OR COND EXIT**
1	A1	0	434.700	.0777	64	43	.700	.626	>1	250	34	
2	1	12	440.643	.0777	78	42	.700		>1	188	34	
3	1	24	446.541	.0777	84	43	.700		>1	182	34	
4	1	36	452.475	.0777	88	45	.700		>1	176	34	
5	1	48	458.432	.0777	90	44	.700		>1	168	34	
6	1	60	464.338	.0777	92	43	.700		>1	168	36	
7	1	72	470.4	.0777	93	45	.700		>1	166	36	
8	2	84	476.289	.0551	95	44	.700		>1	100	38	
9	2	96	482.285	.0551	96	44	.700		>1	100	38	
10	2	108	488.295	.0551	96	46	.700		>1	100	38	
11	2	120	494.294	.0551	98	45	.700		>1	100	38	
12	2	132	500.39	.0551	100	45	.700		>1	117	38	
13	2	144	506.333	.0551	100	48	.700		>1	120	39	
14	2	156	512.357	.0551	100	46	.700		>1	122	39	
15	3	168	518.390	.0593	102	47	.700		>1	122	39	
16	3	180	524.427	.0593	105	47	.700		>1	124	39	
17	3	192	530.436	.0593	105	47	.700		>1	122	39	
18	3	204	536.499	.0593	110	50	.700		>1	126	40	
19	3	216	542.559	.0593	111	52	.700		>1	127	40	
20	3	228	548.777	.0593	112	52	.700		>1	129	40	
21	3	240	555.035	.0593	112	53	.700		>1	128	40	
22	4	252	561.432	.0476	112	54	.700		>1	130	40	
23	4	264	567.381	.0476	110	56	.700		>1	121	40	
24	4	276	573.600	.0476	109	54	.700		>1	118	40	
25	4	288	579.760	.0476	114	55	.700		>1	120	42	

Off 1221 Process Sample On 1223
Stop 1303 Process Start 1305

* FILTER EXIT for NJ Method 1. FILTER BOX for all other
** PROBE EXIT & ✓ (probe & filter heat off) apply to NJ Method 1. COND EXIT applies if sampling train has a condenser

336	170.cc	.0694		48.53	
Min. (θ)	Vm	$(\sqrt{\Delta p})^2$	tm	ts	ΔH

Hi - .771
Low - .518

Stop 1401 Start 1403
Stop 1433 Start 1443

5Lk

ENTROPY

F-1112 (Page 1) 9-

ISOKINETIC TYPE FIELD DATA SHEET (continued)

COMPANY NAME Martin Marietta RUN NUMBER SRkWET121-2
SAMPLING LOCATION Deister Screen DATE 1/2/92

No.	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READINGS CUBIC FEET	PITOT READING IN. H_2O	ORIFICE SETTING IN. H2O IDEAL	ORIFICE SETTING IN. H2O ACTUAL	GAS METER TEMP. °F	VACUUM IN. HG GAUGE	GAS TEMPERATURES FILTER BOX °F	GAS TEMPERATURES IMPINGER EXIT °F	STACK TEMP. °F	LK CHK
26	4	300	586.017	.0476	.626	.70	115	21	123	40	56	
27	4	312	592.430	.0476	.626	.70	115	21	125	40	56	
28	4	324	598.485	.0476	.626	.70	115	21	125	40	57	
29	OFF	336	604.760									
30												
31												
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64												
65												

F1010
9/89
p2

minutes | Vm | $(\sqrt{\Delta p})^2$ | ΔH | tm | ts

ENTROPY

FIELD DATA - METHOD(S)

PLANT Martin Marietta
CITY/STATE Raleigh NC
SAMPLING LOC. Faster Screen
BAROMETRIC PRESSURE, IN. HG 29.7 STATIC PRESSURE, IN. H2O -.25CT
LEAK CHECK, VACUUM IN. HG 15
LEAK RATE, CUBIC FEET/MIN. .002

RUN NO. SR-WET-3-1/6
JOB NO. 3684
DATE 1-6-92
TIME START 0808
TIME FINISH 1450
OPERATOR JTB
ASST(S) JRR, WKK

EQUIPMENT CHECKS*	
N/A	PITOT, PRETEST
N/A	PITOT, POSTTEST
✓	NOZZLE, PRE/POST
✓	TC ~~73~~ 47 °F PRE
	TC °F POST
N/A	ORSAT SYSTEM

FILTER/XAD	TARE WT.
HM214	.3745

EQUIPMENT I.D. NUMBERS

REAGENT BOX L-09 METER BOX N-6 Y .9971
PITOT N/A C_p .84 NOZ'L DES 20 DIA. .345
TC READOUT F-13 TC PROBE R39-K3-3 UMBILICAL -
SAMPL'G BOX - ORSAT PUMP - TEDLAR BAG -

NOMOGRAPH DATA

DELTA Hə	1.779
METER TEMP	100
EST. %H_2O	2
C FACTOR	1.049
STACK TEMP	45
REF DELTA P	.116
K FACTOR	15.331

LEAK CHECKS

B N/A
E

FYRITES

N/A

* PITOT: VISUAL INSPECTION/LEAK CHECK; NOZZLE: VISUAL INSPECTION; TC: AMBIENT TEMPS.; ORSAT SYSTEM: LEAK CHEC

LINE	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READING CUBIC FEET	PITOT READING IN. H2O	GAS METER TEMP. °F	STACK TEMP. °F	ORIFICE SETTING IN. H2O ACTUAL	ORIFICE SETTING IN. H2O IDEAL	GAUGE VACUUM IN. HG	GAS TEMPERATURES °F FILTER *	IMPING. EXIT	PROBE OR COND EXIT**
1	A	0	612.400	.0777	48	47	.700	.621	>1	173	25	
2		12	618.285	.0777	58	44	.700		>1	185	28	
3		24	624.120	.0777	64	44	.750		>1	185	28	
4		36	630.137	.0777	68	45	.750		>1	191	28	
5		48	636.300	.0777	71	45	.750		>1	193	28	
6		60	642.300	.0777	72	44	.750		>1	174	28	
7		72	648.454	.0777	74	44	.750		>1	172	30	
8		84	654.490	.0551	76	45	.750		>1	140	30	
9		96	660.645	.0551	82	45	.750		>1	138	30	
10		108	666.855	.0551	84	45	.750		>1	138	30	
11		120	673.050	.0551	86	48	.750		>1	138	30	
12		132	679.168	.0551	88	47	.750		>1	138	32	
13		144	685.360	.0551	90	51	.750		>1	139	35	
14		156	691.432	.0551	87	51	.750		>1	139	35	
15	3	168	697.555	.0593	87	51	.750		<1	111	34	
16	3	180	703.673	.0593	87	53	.750		<1	106	34	
17	3	192	709.574	.0593	85	54	.750		<1	108	34	
18	3	204	715.900	.0593	86	55	.750		<1	120	34	
19	3	216	721.999	.0593	86	53	.750		<1	125	34	
20	3	228	728.095	.0593	86	54	.750		<1	129	35	
21	3	240	734.289	.0593	86	55	.750		<1	133	36	
22	-	252	740.741	.0476	86	53	.750		<1	133	36	
23	-	264	746.779	.0476	86	54	.750		<1	111	36	
24	-	276	752.405	.0476	86	55	.750		<1	114	36	
25	-	288	758.275	.0476	85	55	.700	✓	<1	118	35	

STOP 935 process down
START 1033
STOP 1044 process
Sample START 1047
1322 STOP process down
1335 START

** PROBE EXIT & ✓ (probe & filter heat off) apply to NJ Method 1.
* FILTER EXIT for NJ Method 1. FILTER BOX for all other. COND EXIT applies if sampling train has a condens

336	170.255	.0694		50.03	
Min. (θ)	Vm	$(\sqrt{\Delta p})^2$	tm	ts	ΔH

5.6 Hr

ΔH +50 .515
ΔH -50 .7466

ENTROPY

ISOKINETIC TYPE FIELD DATA SHEET (continued)

COMPANY NAME Martin Marietta RUN NUMBER SR-WET-3-1-6
SAMPLING LOCATION Fine Screen DATE 1-6-92

No.	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READINGS CUBIC FEET	PITOT READING IN. H2O	ORIFICE SETTING IN. H2O IDEAL	ORIFICE SETTING IN. H2O ACTUAL	GAS METER TEMP. °F	VACUUM IN. HG GAUGE	GAS TEMPERATURES FILTER BOX °F	GAS TEMPERATURES IMPINGER EXIT °F	STACK TEMP. °F	LA[illegible] CHK
26	-	300	764.733	.042	.621	.700	84	<1	125	36	54	
27	-	312	770.243	.042		700	83	<1	126	36	54	
28	-	324	776.85[illegible]	.042	↓	700	81	<1	127	35	54	
29	---	336	782.655									
30												
31												
32												
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64												
65		-										

F1010
9/89
22

minutes | Vm | $(\sqrt{\Delta p})^2$ | ΔH | tm | ts

FIELD DATA - METHOD(S)

PLANT Martin Marietta
CITY/STATE Raleigh NC
SAMPLING LOC. Dexter Screen
BAROMETRIC PRESSURE, IN. HG 29+
STATIC PRESSURE, IN. H2O -28.07
LEAK CHECK, VACUUM IN. HG 15
LEAK RATE, CUBIC FEET/MIN. .000

RUN NO. Blank Duct
JOB NO. 3684
DATE 4-6-92
TIME START 1540
TIME FINISH
OPERATOR TTB
ASST(S) JRR, HW

EQUIPMENT CHECKS*

N/A PITOT, PRETEST
N/A PITOT, POSTTEST
NOZZLE, PRE/POST
✓ TC ___ °F PRE
TC ___ °F POST
ORSAT SYSTEM

EQUIPMENT I.D. NUMBERS

REAGENT BOX N/A
METER BOX N-6
Y .9871
PITOT —
Cp —
NOZ'L D85.309
DIA. .343
TC READOUT F-23
TC PROBE R299-R303
UMBILICAL —
SAMPL'G BOX —
ORSAT PUMP —
TEDLAR BAG —

LEAK CHECKS

B N/A
E

FILTER/XAD | **TARE WT.**

FILTER/XAD	TARE WT.
4MV05	.2714

NOMOGRAPH DATA

DELTA H@ 1.779
METER TEMP 100
EST. %H2O 2
C FACTOR 1.049
STACK TEMP 52 45
REF DELTA P .116
K FACTOR 15.831

PYRITES

N/A

* PITOT: VISUAL INSPECTION/LEAK CHECK; NOZZLE: VISUAL INSPECTION; TC: AMBIENT TEMPS.; ORSAT SYSTEM: LEAK CHE

LINE	SAMPLE POINT	CLOCK TIME MINUTES	DRY GAS METER READING CUBIC FEET	PITOT READING IN. H2O	GAS METER TEMP. °F	STACK TEMP. °F	ORIFICE SETTING IN. H2O ACTUAL	ORIFICE SETTING IN. H2O IDEAL	GAUGE VACUUM IN. HG	GAS TEMPERATURES °F FILTER *	IMPING. EXIT	PROBE OR COND EXIT**
1	A-2	0	782.812	.0551	70	55	.75	.621	71	70	N/A	
2	2	15	794.273	.0551	73	52	.75	|	<1	140		
3	2	30	808.730	.0551	78	55	.75	|	<1	160		
4	2	~~45~~ 60	812.565	.0551	78	56	.75	|	<1	161		
5												
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1555 ~~1600~~
1610 ~~1615~~
1625 ~~1630~~
1640

1603
1636

** PROBE EXIT & ✓ (probe & filter heat off) apply to NJ Method 1.

* FILTER EXIT for NJ Method 1. FILTER BOX for all ot... COND EXIT applies if sampling train has a conde...

Min. (θ)	Vm	$(\sqrt{\Delta p})^2$	tm	ts	ΔH
60	29.753	.0551		54.5	

29.9 49.2
29.3

ENTROPY

F-1112 (Page 1)

MOISTURE ANALYTICAL RESULTS

Plant Name Martin Marietta Job No. 3684

City/State Raleigh NC Sampling Loc. Deister Screen

Run Number	SC/~~WET~~ DRY/1/12-17	SR-/~~WET~~ DRY 2/12-19	SR-/~~WET~~ DRY 3/12/12
Sampling Date	12-17-91	12-19-91	12-19-91
Analysis Date			
Analyst			

Reagent 1 (200 ml H_2O)			
Final Weight, g	552.0	564.8	550.8
Tared Weight, g	551.0	583.5	576.5
Water Catch, g	1.0g	-18.7	-25.7
Reagent 2 (______)			
Final Weight, g			
Tared Weight, g			
Water Catch, g			
Reagent 3 (______)			
Final Weight, g			
Tared Weight, g			
Water Catch, g			
CONDENSED WATER, g			

Silica Gel			
Final Weight, g	202.3	210.8	213.3
Tared Weight, g	197.2	206.7	208.5
ADSORBED WATER, g	5.1g	4.1	4.8

TOTAL WATER COLLECTED, g	6.1g	5.4	7.1
		+BF 20.0g	+BF 28g

Balance No. 12 Type (✓) Triple Beam ✓ Electronic ___ Reagent Box No. ______

Balance located in stable, draft-free area (✓)? Yes ___ No ___ (If "No", explain below.)

Comments ____________________

ENTROPY

MOISTURE ANALYTICAL RESULTS

Plant Name Martin Marietta Job No. 3684

City/State Raleigh Sampling Loc. Deister Screen

Run Number	SR/WET/1/12-20	SR/WET/2/1-2	SR/WET/3/1-2
Sampling Date	12/20/91	1-2-92	1-2-92
Analysis Date			
Analyst			
Reagent 1 (200g H_2O)			
Final Weight, g	598.0	570.8	593.4
Tared Weight, g	583.5	584.0	568.5
Water Catch, g	14.5	-13.2	24.9
Reagent 2 (____)			
Final Weight, g			
Tared Weight, g			
Water Catch, g			
Reagent 3 (____)			
Final Weight, g			
Tared Weight, g			
Water Catch, g			
CONDENSED WATER, g			
Silica Gel			
Final Weight, g	228.2	233.7	234.8
Tared Weight, g	214.9	209.7	210.5
ADSORBED WATER, g	13.3	24.0	24.3
TOTAL WATER COLLECTED, g	27.8	10.8	49.2

Balance No. 12 Type (✓) Triple Beam ✓ Electronic ___ Reagent Box No. ____

Balance located in stable, draft-free area (✓)? Yes ___ No ___ (If "No", explain below.)

Comments ____

L-0036 12-91

ENTROPY

ISOKINETIC METERBOX FULLTEST CALIBRATIO

Meterbox No. N6　　　　Calibrated By MBC

Date 8-20-91　　　　Barometric Pressure (P_b) 29.35 (In

Date ______________.　　　　Barometric Pressure (P_b) ________ (In.

Standard Meter No. 3586003　　　　Standard Meter Coefficient .990

STANDARD METER			METERBOX METERING SYSTEM				
Gas Volume (V_{ds}) cf	Temp. (t_{ds}) °F	Time (θ) Min.	Orifice Setting (ΔH) In. H2O	Gas Volume (V_d) cf	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H@$ In. H_2
4.114	77	10	0.5	4.218	85	.9795	1.720
4.092	77		0.5	4.195	86	.9822	1.733
7.934	78		2.0	8.134	91	.9849	1.836
7.832			2.0	8.081	95	.9857	1.831
12.350			4.8	12.743	105	.9965	1.774
12.327	↓	↓	4.8	12.756	105	.9936	1.78
					Average	.9871	1.774

1. Coefficient range: 0.97-1.03.
2. Coefficient tolerance: for individual runs, ± 0.02 from average.
3. $\Delta H@$ range: 1.6-2.0.
4. $\Delta H@$ tolerance: ≤ 0.15 In. H_2O over ΔH range of 0.4 In.-4.0 In.

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + (\Delta H / 13.6))}$$

$$\Delta H@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}}\right]^2$$

R-0030 rev. 2-90

ENTROPY

Dry Gas Meter Identification: 3586003 Calibration by: WLS

Date: 8-14-91 Barometric Pressure (P_b): 29.82 in. Hg

PAGE 1 OF 2

ENTROPY ENVIRONMENTALISTS, INC.

*Date: ________ *Barometric Pressure (P_b): ________ in. Hg

	Spirometer		Dry Gas Meter						
	Gas Volume (V_s) ft^3	Temp. (t_s) °F	Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (Θ) min.	Flow Rate (Q)	Meter Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
	2.76	75	2.795	76	-.43	10	.23	.9904	NA
	2.75		2.765	76	-.43		.23	.9975	
	2.76		2.762	76	-.43		.23	1.0022	
	4.098		4.151	74	-.47		.55	.9865	
	4.089		4.136	74	-.47		.55	.9879	
	4.089		4.130	74	-.47		.55	.9854	
	4.927		4.985	76	-.95		.80	.9925	
	5.009		5.059	76	-.95		.80	.9943	
	4.964		5.042	76	-.95		.80	.9887	
	8.097		8.253	78	-2.2		2.10	.9920	
	8.078		8.237	78	-2.2		2.10	.9916	
	7.987		8.159	78	-2.2		2.10	.9898	
	10.383		10.636	78	-3.4		3.45	.9900	
	10.300		10.537	78	-3.4		3.45	.9913	
	10.300		10.552	78	-3.4		3.45	.9899	
	12.523		12.813	78	-4.95		4.70	.9904	

$(V_s)\ (t_{ds} + 460)\ (P_b)$

Dry Gas Meter Identification: 3586003 Calibration by: WLS

Date: 8-14-91 Barometric Pressure (P_b): 29.82 in. Hg

PAGE 2 OF 2

ENTROPY ENVIRONMENTALISTS, INC.

*Date: ______ *Barometric Pressure (P_b): ______ in. Hg

	Spirometer		Dry Gas Meter						
	Gas Volume (V_s) ft^3	Temp. (t_s) °F	Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (Θ) min.	Flow Rate (Q)	Meter Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
	12.259	75	12.626	78	-4.95	10	4.70	.9884	NA
	12.077		12.441	78	-4.95		4.70	.9882	
	13.661		14.108	79	-5.70		5.80	.9895	
	13.652		14.107	79	-5.70		5.80	.9889	
	13.452		13.925	79	-5.70		5.80	.9871	

Y_{ds} = ~~.9908~~

$(V_s)\ (t_{ds} + 460)\ (P_b)$

APPENDIX D

Sampling Log and Chain-of-Custody Records

RECORD OF CUSTODY, CONTAINER NO. 0574

Container Type (check) ✓ Reagent Box ___ Cooler ___ Other ______

Plant Name/Address Martin Marietta

Job No. 3684 Sampling Method M201A (EPA, NIOSH, etc.)

Seal ID	Date	Time	*	Full Signature	Reason for Breaking Seal**
2291	12-12	4:30	S	Billy L. Bell	
	12-17	2:47	B	Todd Brozell	Charge Trains
977	12-19	6:37	S	Todd Brozell	
			B		
			S		
			B		
			S		
			B		
			S		
			B		
			S		
			B		
			S		
			B		
			S		
			B		

* S = Sealed By; B = Broken By ** Use "REMARKS" Section if more space needed.

Received by Sample Custodian

[illegible] ______ Signature [illegible] ______ Date [illegible] ______ Time

**Seal Intact? ✓ Yes ___ No

As Applicable:
All liquid levels at mark (check)? ___ YES ___ NO (Estimate loss if not at mark; describe in "REMARKS")

As Applicable:
TUBE SAMPLES put in freezer by ______ Date ______ Time ______

CONDENSATE SAMPLES put in refrige. by ______ Date ______ Time ______

REMARKS ______

L-0023 rev. 10-91

ENTROPY

FIELD SAMPLE RECOVERY QUALITY CONTROL

Box No. 0574 Assembly Date 12-12-91 Assembled By B.B.

Plant Name/Address Martin Marietta Job No. 3684

Sampling Loc. Crusher Raleigh Method 201A

Individual Tare of Reagent 200 (mL) ~~(gm)~~ of DI H_2O

Individual Tare of Reagent ______ (mL)(gm) of ______

Individual Tare of Reagent ______ (mL)(gm) of ______

Individual Tare of Sil. Gel ~200 gm ______ Other (specify)

Run Number	Run Date	Filter Number	Filter Tare, grams	Liquid Tare at Mark? @	Init.	Sample Recov. Date	%Sil. Gel Spent	Liquid Level Marked?	Init.
~~SR/DRY~~/1/12-17	12-17	PM64	.2726	✓	TTB	12-17	5	✓	TTB
SR ~~Dry~~ DRY Filter Rinse Cyclone + Nozzle Rinse				Filter Appearance* Light Grey Reagents Appearance* Clear					
SR/DRY/2/12-19	12-19	PM66	.2753	✓	TTB	12-19	5	✓	TTB
				Filter Appearance* Grey Reagents Appearance* Clear					
SR/DRY/3/12-19	12-19	PM68	.2734	✓	TTB	12-19	5	✓	TTB
				Filter Appearance* Light Reagents Appearance* Clear					
				Filter Appearance* Reagents Appearance*					

* Use "REMARKS" section if needed.

@ All liquid levels at mark? (check) YES ___ NO ___ (estimate loss if not at mark; use "REMARKS" section).

REMARKS ______

DRY [illegible]

RECORD OF CUSTODY, CONTAINER NO. 609

Container Type (check) ✓ Reagent Box ___ Cooler ___ Other ______

Plant Name/Address Martin Marietta

Job No. 3684   Sampling Method M201A   (EPA, NIOSH, etc.)

Seal ID	Date	Time	*	Full Signature	Reason for Breaking Seal**
2245	12-12	4:30	S	[illegible signature]	
	12-20	900	B	Todd Brozell	Chg Trains
0537	1-1	1630	S	Todd Brozell	
			B		
			S		
			B		
			S		
			B		
			S		
			B		
			S		
			B		
			S		
			B		
			S		
			B		

* S = Sealed By; B = Broken By   ** Use "REMARKS" Section if more space needed.

Received by Sample Custodian

DRP [signature]   12-8-92   0930   **Seal Intact? ✓ Yes ___ No

Signature   Date   Time

As Applicable:
All liquid levels at mark (check)? ___ YES ___ NO (Estimate loss if not at mark; describe in "REMARKS")

As Applicable:
TUBE SAMPLES put in freezer by ______ Date ______ Time ______

CONDENSATE SAMPLES put in refrige. by ______ Date ______ Time ______

REMARKS ______

L-0023 rev. 10-91

ENTROPY

FIELD SAMPLE RECOVERY QUALITY CONTROL

Box No. 609 Assembly Date 12-12-91 Assembled By B.B.

Plant Name/Address Martin Marietta Job No. 3684

Sampling Loc. Deister Screen Method 201A

Individual Tare of Reagent 200 (mL)(gm) of DI H_2O

Individual Tare of Reagent ____ (mL)(gm) of ____

Individual Tare of Reagent ____ (mL)(gm) of ____

Individual Tare of Sil. Gel ~200 gm ____ Other (specify)

Run Number	Run Date	Filter Number	Filter Tare, grams	Liquid Tare at Mark? @	Init.	Sample Recov. Date	%Sil. Gel Spent	Liquid Level Marked?	Init.
SR/WET/1/12-20	12-20	PM220	.2730	✓	TTB	12-20	5	✓	TTB
Cyclone & Nozzle Rinse.				Filter Appearance*					
Filter				Reagents Appearance*					
Filter Rinse									
SR/WET/2/1-2	1-2	PM219	.2737	✓	TTB	1-2	25	✓	TTB
"				Filter Appearance*					
"				Reagents Appearance*					
"									
SR/WET/3/1-6	1-6	PM218	.2745	✓	TTB	1-6	20	✓	TTB
"				Filter Appearance*					
"				Reagents Appearance*					
"									
Duct Blank	1-6	PM65	.2714	✓	TTB	1-6	N/A	✓	TTB
"				Filter Appearance*					
"				Reagents Appearance*					

* Use "REMARKS" section if needed.

@ All liquid levels at mark? (check) YES ___ NO ___ (estimate loss if not at mark; use "REMARKS" section).

REMARKS ____

[signature] 1-7-92

Q-1002 rev. 6-91

ENTROPY

APPENDIX E.

Analytical Data

PARTICULATE SAMPLING LABORATORY RESULTS

Plant Name: MARTIN MARIETTA

EEI Ref# 3684

Sampling Location: Deister Screen

Date Received: 01/08/92 Date Analyzed: 01/14/92

Run Number	init.	date		SR/DRY-1	date		SR/DRY-2	date		SR/DRY-3
Sample ID/Container #				F / 312			F / 314			F / 316
	JBN	01/14		3.8196						
	JBN	01/13	@	3.8193						
	JC	01/10		3.8187	01/10	@	3.8072	01/10	@	3.8416
	VP	01/09		3.8197	01/09		3.8075	01/09		3.8417
Baggie Tare Wt., g.				3.5417			3.4999			3.5601
Filter Tare Wt., g.				0.2726			0.2753			0.2734
DRY PARTICULATE WT., g.				0.0050			0.0320			0.0081

	init.	date			date			date		
Sample ID/Container #				R / 313			R / 315			R / 317
								01/14		3.5858
	JBN	01/13		3.7139	01/13		3.5314	01/13	@	3.5856
	JC	01/10	@	3.7134	01/10	@	3.5309	01/10		3.5844
Tare Wt., g.				3.7112			3.5273			3.5824
SAMPLE WT., g.				0.0022			0.0036			0.0032

		SR/DRY-1		SR/DRY-2		SR/DRY-3
Total Particulate., mg.		7.2		35.6		11.3
Blank Residue, mg.	(100 ml)	0.2	(100 ml)	0.2	(60 ml)	0.1
TOTAL PARTICULATE CATCH, mg.		7.0		35.4		11.2

Blank Beaker #	2003
Final wt., mg.	99546.3
Tare wt., mg.	99545.9
Residue, mg.	0.4
Volume, ml.	200
Conc., mg/ml	0.002

—Legend—

@ = Final Weight

F = Filter R = Rinse

1 = Light 2 = Medium

3 = Heavy or Dark

Sample Description

Run #	Color	Loading
-1	1 2 3	1 2 3
-2	1 2 3	1 2 3
-3	1 2 3	1 2 3

Notes and comments:

Predominate color of samples is: Cream

Date of full balance span 01/06/92

PARTICULATE SAMPLING LABORATORY RESULTS

Plant Name: MARTIN MARIETTA — EEI Ref# 3684

Sampling Location: Deister Screen

Date Received: 01/08/92 — Date Analyzed: 01/14/92

Run Number	init.	SR/WET-1 date		SR/WET-1	SR/WET-2 date		SR/WET-2	SR/WET-3 date		SR/WET-3
Sample ID/Container #				F / 318			F / 320			F / 322
	JC	01/10		3.8930	01/10		3.9583	01/10	@	3.8137
	VP	01/09	@	3.8929	01/09	@	3.9579	01/09		3.8140
Baggie Tare Wt., g.				3.6151			3.6758			3.5266
Filter Tare Wt., g.				0.2730			0.2737			0.2745
DRY PARTICULATE WT., g.				0.0048			0.0084			0.0126

	init.	SR/WET-1 date		SR/WET-1	SR/WET-2 date		SR/WET-2	SR/WET-3 date		SR/WET-3
Sample ID/Container #				R / 319			R / 321			R / 323
								01/14		3.753[illegible]
	JBN	01/13		3.5360	01/13		3.5016	01/13	@	3.753[illegible]
	JC	01/10	@	3.5358	01/10	@	3.5011	01/10		3.7526
Tare Wt., g.				3.5331			3.4978			3.7494
SAMPLE WT., g.				0.0027			0.0033			0.0038

	SR/WET-1		SR/WET-2		SR/WET-3	
Total Particulate., mg.		7.5		11.7		16.4
Blank Residue, mg.	(225 ml)	0.5	(75 ml)	0.2	(75 ml)	0.2
TOTAL PARTICULATE CATCH, mg.		7.0		11.5		16.2

Blank Beaker #	2003
Final wt., mg.	99546.3
Tare wt., mg.	99545.9
Residue, mg.	0.4
Volume, ml.	200
Conc., mg/ml	0.002

—Legend—

@ = Final Weight

F = Filter R = Rinse

1 = Light 2 = Medium
3 = Heavy or Dark

Sample Description

Run #	Color	Loading
- 1	1 2 3	1 2 3
- 2	1 2 3	1 2 3
- 3	1 2 3	1 2 3

Notes and comments:

Predominate color of samples is: Grey

Date of full balance span 01/06/92

PARTICULATE SAMPLING LABORATORY RESULTS

Plant Name: MARTIN MARIETTA

EEI Ref# 3684

Sampling Location: Deister Screen

Date Received: 01/08/92 Date Analyzed: 01/14/92

Run Number DUCT BLANK

Sample ID/Container # F / 325

	init.	date		F / 325
	JBN	01/13		3.9778
	JC	01/10	@	3.9775
Baggie Tare Wt., g.				3.7061
Filter Tare Wt., g.				0.2714
DRY PARTICULATE WT., g.				0.0000

Sample ID/Container # R / 326

	init.	date		R / 326
	JBN	01/14		3.5477
	JBN	01/13	@	3.5472
	JC	01/10		3.5633
Tare Wt., g.				3.5468
SAMPLE WT., g.				0.0004

Total Particulate., mg.		0.4
Blank Residue, mg.	(25 ml)	0.1
TOTAL PARTICULATE CATCH, mg.		**0.3**

Blank Beaker #	2003
Final wt., mg.	99546.3
Tare wt., mg.	99545.9
Residue, mg.	0.4
Volume, ml.	200
Conc., mg/ml	0.002

—Legend—
@ = Final Weight
F = Filter R = Rinse

1 = Light 2 = Medium
3 = Heavy or Dark

Sample Description

Run #	Color	Loading
- DB	1 2 3	1 2 3

Notes and comments:
Predominate color of samples is:
Date of full balance span 01/06/92

Oxford Laboratories, Inc.
Analytical and Consulting Chemi
1316 South Fifth Str
Wilmington, N.C. [illegible]
(919) 763-[illegible]

DATE RECEIVED 01-20-92
DATE REPORTED 01-30-92
92W5251

ENTROPY ENVIRONMENTALIST INC.
P. O. BOX 12291
RESEARCH TRIANGLE PARK, NC 27709-2291

P.O. # 1983-3684

ATTENTION: RICHARD TEBEAU

SAMPLE DESCRIPTION: CRUSHED GRANITE

1. GAR/WET/1/12-10
2. GAR/DRY/2/12-9
3. SR/WET/3/1-6
4. SR/DRY/2/12-19
5. METHOD CODE SW846-

RESULTS

	1	2	3	4	5
Cadmium, as Cd, ug/g	<3.80	<3.67	<2.25	<3.85	7131
Nickel, as Ni, ug/g	315	628	35.1	19.2	7521
Lead, as Pb, ug/g	75.4	81.8	27.8	30.6	7421

Roger C. Oxford
ROGER C. OXFORD, CHEMIST

INTERLABORATORY SAMPLE TRANSFER
RECORD OF CUSTODY

Please include this form with the final (typed) results, and whenever the final results are faxed.

The samples referenced in Entropy Environmentalists Inc. purchase order No. 1983-3684 were shipped via Pony on 1-17-92 to OLI by John V. [illegible].

The samples were received at OLI on 1-20-92 by MBC.

Note any broken seals, leakage, spillage, or damage to samples (*if discrepancy, indicate seal No., jar No., sample No., etc.*).

L-0012 rev. 8-91

ENTROPY

APPENDIX F.

Audit Data Sheets

SAMPLING EQUIPMENT AUDIT

Plant Name Martin Marietta

City/State Garner, NC Job No. 3684

Test Loc. Lower Outlet of Crusher Auditor(s) GCB

Date 9 Dec 91

BAROMETER

Entropy In-House Ref. Barometer ______ "Hg vs Field Barometer ______ "Hg

Date Compared ______ Dev. ______ "Hg (Max. Allowable Dev.: ± 0.1 "Hg)

Ref. Therm. Initial Ambient Temp., °F ______

THERMOMETERS *	Allowable Deviation From Ambient	Ambient Temperature, °F				Audit OK (√)
Dry Gas Meter	± 5.4 °F	______	(Meterbox No. ______)			
Impinger Exit	± 2.0 °F	______				______
Filter Box	± 5.4 °F	______	______	______	______	______
		______	______	______	______	______

* Adjust thermometer until acceptable. If it cannot be adjusted, use as back-up. If no backup, record ambient temperature indicated by unadjusted thermometer and label with correction factor (indicate):

THERMOCOUPLES Allowable Deviation from Ambient: ± 8.0°F* (± 2.0°F)**

TC No./ °F	OK √	TC No./ °F	OK √	TC No./ °F	OK √	TC No./ °F	OK √	TC No./ °F	OK √
/		/		/		/		/	

* ± 8.0 °F = ± 1.5% of ambient absolute temperature.
** (± 2.0 °F if used in saturated or water droplet-laden gas stream.)

ISOKINETIC METERBOX I.D. U6 Gamma (Y) .9871 ΔH@ 1.779

As Applicable (check): Zero Magnehelics? ______ Zero/Level Manometer? ______

Barometric Pressure (P_{bar}) 30.0 Auditor GCB Date 9 Dec 91

Dry Gas Meter Reading (Cubic Ft.)	Meter Temperature (°F)	Lower and Upper Limits for Audit Gamma
Final 761.130	Final 92	0.96 * Y = .94761
Initial 753.600	Initial 82	1.04 * Y = 1.02658

Dry Gas Volume Metered (Cubic Ft.)	Average Meter Temp. (°F)	Run Time (Base = 10) (Minutes)	(Seconds)
Vm = 7.53	Tm = 87	10	0

$$Y_c = \frac{[\text{Min.} + (\text{Sec.} / 60)]}{V_m} * \left[\frac{0.0319\,(T_m + 460)}{P_{bar}}\right]^{1/2}$$

$$Y_c = \frac{[10 + (0 / 60)]}{7.53} * \left[\frac{0.0319\,(87 + 460)}{30.0}\right]^{1/2} = 1.01282$$

Audit Gamma

Audit Gamma Acceptable (between lower & upper limits)? (√) √ Yes ______ No

F-1113 9-91

ENTROPY

APPENDIX G.

List of Participants

KEY PERSONNEL

The key personnel who coordinated the test program and their telephone numbers are:

• Mr. Solomon Ricks Field Test Coordinator, EMB	919/541-5242
• Mr. Dennis Holzschuh Field Test Coordinator, EMB	919/541-5239
• Mr. Horace Wilson Martin Marietta Corporate Contact	919/781-4550
• Mr. Steve Witt Martin Marietta Corporate Contact	919/781-4550
• Mr. John Richards, Phd, P.E. Project Manager, Entropy	919/781-3551
• Mr. Todd Brozell Field Test Director, Entropy	919/781-3551
• Mr. William Kirk Meteorological and Process Data Coordinator, Entropy	919/781-3551
• Mr. Harold Lee Field Sampling Technician, Entropy	919/781-3551

APPENDIX H.

Method 201A (PM10)
Standard Operating Procedures Manual

METHOD 201A (PM-10)
Standard Operating Procedures Manual

September 5, 1991
Jeff Kunstling
Rev'n # 1.0

Method 201A (Determination of PM_{10} emissions)

TABLE OF CONTENTS

METHOD 201A

DETERMINATION OF PM_{10} EMISSIONS
(Constant Sampling Rate Procedures)

1. APPLICABILITY AND PRINCIPLE.

1.1 Applicability.

This method applies to the in-stack measurement of particulate matter (PM) emissions equal to or less than an aerodynamic diameter of nominally 10 μm (PM_{10}) from stationary sources.

1.2 Principle.

A gas sample is extracted at a constant flow rate through an in-stack sizing device which separates the PM_{10} particulate from the rest of the particulate matter. Variations from isokinetic sampling conditions are maintained within well defined limits. The particulate mass is determined gravimetrically after removal of uncombined water.

2. APPARATUS.

2.1 Sampling train. This method can be performed using an apparatus similar to Method 5 or similar to Method 17.

2.1.1 Probe nozzle. Use stainless steel nozzles provided with the cyclone.

2.1.2 PM_{10} sizer. Use stainless steel cyclone particle sizer.

2.1.3 In stack filter holder. Use 63 mm stainless steel filter holder that matches with the in-stack cyclone.

2.1.4 For saturated sources, heat wrap is needed for the nozzle, cyclone and filter holder.

2.1.5 Pitot tube. Use the modified S-type Pitot tubes that are extended and widened to accommodate the cyclone/filter holder assembly.

2.1.6 Probe liner. Use stainless steel or glass liner. If possible, use the stainless steel liner because the glass liners tend to break easily with the particle sizer attached. Probe should be heated to avoid condensation.

2.1.7 Depending on what sampling train is used, either a filter by-pass and heated filter compartment will be used for the Method 5 type train or metal L's, metal U's, and a vacuum jumper will be used for the Method 17 type train.

2.1.3 Differential pressure gauge, condenser, metering system, barometer, gas density determination equipment. Same as for Method 5.

2.2 Sample recovery.

2.2.1 Use nylon bristle brushes with stainless steel wire shafts and handles, properly sized and shaped for cleaning the nozzle, sizing device, probe liner, and filter holder.

2.3 Analysis. Same as in Method 5.

3. REAGENTS. (Same as for Method 5)

3.1 Sampling.

3.1.1 Filters. Use glass fiber filters exhibiting at least 99.95% efficiency (<.05% penetration) on 0.3 micron dioctyl phthalate smoke particles.

3.1.2 Silica gel. Use indicating type 6 to 16 mesh.

3.1.3 Water. Use distilled water.

3.2 Sample recovery.

3.2.1 Acetone - reagent grade (<.001% residue)

3.3 Analysis.

3.3.1 Desiccant. Use indicating type such as anhydrous calcium sulfate.

4. PROCEDURE.

4.1 Pretest preparation. (Same as for Method 5)

4.2 Cyclone/Filter Holder Assembly.

4.2.1 The two filter holders we use require two different sizes of filters. Some filters fit both filter holder assemblies, and some only fit one or the other. This information can be found on the petri dishes that the filters come in. Special attention must be given to the filter size when assembling the filters.

4.2.2 Open the filter holder and place the filter on th filter support screen. (Note: One of the filter holder has a removable filter support screen that is rough c one side and smooth on the other. This screen needs t be placed so that the filter rests on the smooth side.

4.2.3 Assemble the filter holder and cyclone, making sur that the Viton O-rings are in good condition, an tighten all the connections securely. Teflon tape ma be needed to insure a good seal; however, this needs t be done very carefully. If any of the tape is expose to the inside of the cyclone or filter holder, it wil tear off and catch on the filter, possibly voiding th run. Therefore, extreme care must be taken to insur that only the outer threads are wrapped with the Teflor tape.

4.2.4 Remove the sticker containing the filter number and tare weight from the petri dish and place it on the filter holder.

4.2.5 Once the nozzle has been selected and attached to the cyclone, leak check the entire train from the nozzle back. The cyclone/filter holder assembly is going to leak quite a bit, so the rest of the train needs to be in very good shape. The cyclone/filter holder assembly will be removed prior to the post-test leak check, so if the pre-test leak rate is at or below 0.02 cfm with the majority of the leak being attributed to the cyclone/filter holder assembly, there should be no problem in obtaining a good run.

4.3 Site Requirements.

4.3.1 Use a sampling port diameter of 6 inches. This is required for nozzle diameters greater than 0.16 inches and preferred in all cases.

4.3.2 Cross sectional area of the sampling assembly must not be greater than 3% of the duct. The cross sectional area of our sampling assembly is 18.75 square inches. This translates into a minimum duct sizes of 28.25" diameter for a circular duct or 625 square inches for a rectangular stack (about 25" by 25"). For smaller ducts, sampling is still possible using a Method 2A type setup with a standard Pitot.

4.3.3 For saturated sources, use heat wrap to heat the cyclone/filter assembly to 50°F above the stack temperature.

4.4 Preliminary determinations. Same as Method 5 except use the directions in this method for nozzle size selection and sampling time.

4.4.1 The maximum number of traverse points for any location shall be 12. Use the standard Method 1 procedure for a 12 point traverse to determine the location of these 12 points. (See Section 10.1)

4.4.2 Preform a preliminary traverse, recording the velocity head (ΔP) and the stack temperature (t_s) at each point on a Air Flow Rate Determinations (Method 2) data sheet. (See Section 10.2)

4.4.3 Using the laptop computer with the "PM10CALC" file loaded, enter the average ΔP and average t_s from the preliminary traverse along with the other required data such as moisture, pressure, etc. A listing of all the equations that are used is presented in the calculations section.

4.4.4 The computer will give information such as ΔH, $\Delta H_{t+50°}$, $\Delta H_{t-50°}$, and the desired nozzle diameter which are to be recorded on the Method 201A field data sheet. (See Section 10.6)

4.4.5 Choose the two nozzles from the nozzle box closest in diameter to the desired nozzle diameter (one higher and one lower) and enter them into the computer one at a time where the nozzle selected is asked for. Record onto the data sheet the ΔP_{min} and the ΔP_{max} that the computer calculates for each nozzle.

4.4.6 Examine the range of ΔPs from the preliminary traverse and select the nozzle which best incorporates the range of ΔPs. Ideally, all 12 points should fall between the ΔP_{min} and the ΔP_{max} of one of the nozzles; however, it is permissible to have one point fall outside the range if the isokinetics for the run are between 80% and 120%. If neither nozzle meets these conditions, a nozzle change during the run will be required.

NOTE: See section 4.6.1 on nozzle changes.

4.4.7 Calculate the dwell time for the first point using the equation presented in section 7.1.15. Calculate the dwell time for all subsequent points using the equation presented in section 7.1.16.

NOTE: The method calls for the calculation of the dwell times as you proceed through the test. When the probe is moved to the next point, the ΔP is read and then used to calculate the dwell time for the point. However, in order to simplify matters and to make the run more predictable, we have elected to use the ΔPs from the preliminary traverse to calculate the dwell times and assume that they remain essentially constant during the run. The benefits of this are that it allows us to calculate and check the dwell times for each point prior to testing, and it also eliminates the possibility of points unexpectedly dropping out of the nozzle's range.

4.5 Sampling.

4.5.1 Preform a pre-test leak check through the entire sampling train.

4.5.2 Allow the sizing device to reach stack temperature by placing it in the stack for 20 to 30 minutes prior to the run.

4.5.3 Position the probe at the first sampling point and begin sampling at the ΔH determined by the computer.

4.5.4 Record the appropriate data onto the field data sheet.

NOTE: Record the ΔP and t_s from the preliminary traverse onto the field data sheet for the corresponding points. The ΔP and t_s actually encountered during the run need not be recorded.

4.5.5 After the dwell time for the first point has elapsed, move on to the next point using the same ΔH.

NOTE: See section 4.6.2 on changing the ΔH.

4.5.6 Continue until all points have been sampled.

4.5.7 At the conclusion of the run, remove the cyclone/filter holder assembly **BEFORE** performing the post-test leak check.

4.5.8 After removing the cyclone/filter holder assembly, keep it in an upright position (cyclone up, filter down) and cover the openings with tape until it has cooled enough to clean. See section 4.7 on sample recovery.

4.5.9 Leak check the train from the front of the probe liner back at the highest vacuum observed during the run.

4.5.10 If a Method 17 type train is being used, drain the umbilical.

4.6 Special Cases.

4.6.1 Nozzle Change During The Run.

1. If there is more than one point with a ΔP that is out of the range of the selected nozzle, a nozzle change will be required during the run.

2. Sample all the points within the range of the selected nozzle, skipping over the points that fall outside of the range.

3. After all the points that are within the nozzles range have been sampled, stop the run and remove the probe from the stack. As soon as the nozzle has cooled enough to handle, remove the nozzle and replace it with the next nozzle. Do NOT preform a leak check.

4. Tape over the old nozzle and place it aside to be cleaned up with the cyclone catch after the run.

5. Position the probe at the first traverse point that has not yet been sampled and is in the new nozzles ΔP range. Allow the cyclone/filter holder assembly to reach stack temperature and resume sampling AT THE SAME ΔH.

6. The points sampled with the new nozzle must be clearly noted on the data sheet. Changing the nozzle diameter requires the isokinetic sampling rate for the run to be calculated as a time weighted average of the isokinetic sampling rates achieved during each segment of the run involving a different nozzle. To do this the exact points using each nozzle must be known.

7. If three or more nozzles are required, repeat the same procedure for each of the nozzles used.

4.6.2 ΔH Change During The Run.

1. In general, the entire run will be done using the same ΔH, even if the nozzle is changed.

2. The only time the ΔH is changed is if the stack temperature at a sampling point varies by more than 50°F from the average stack temperature that was determined by the preliminary traverse.

3. During the preliminary calculations, values were obtained for $\Delta H_{t+50°}$ and $\Delta H_{t-50°}$ and recorded o

the field data sheet. These are the respectiv values that are to be used for ΔH if the stac temperature is 50°F higher or lower than th average stack temperature.

4. If a point with a 50° temperature variation i encountered during the run, adjust the meter bo to the appropriate temperature adjusted value fo ΔH at the beginning of the point.

5. If the next point is back within 50°F of the average stack temperature, go back to the origina ΔH.

6. Changing the ΔH will not have an effect on the way that the isokinetics are calculated.

4.7 Sample Recovery.

4.7.1 Assemble the required clean-up containers.

1. Quart jar originally containing the 200 ml H_2O.
2. Plastic bottle originally containing silica gel.
3. Pint jar labelled "nozzle and cyclone rinse."
4. Pint jar labelled "2 in. filter front half rinse."
5. Small jar labelled "2 in. filter."

4.7.2 Pour the H_2O from the impingers back into its original quart jar, weigh, and record.

4.7.3 Pour the silica gel back into its original container, weigh, and record.

4.7.4 Keeping the cyclone/filter holder assembly upright (cyclone up, filter down), remove the top plate with a wrench. The "turn around cup" is the small cup-like piece attached to the top of the cyclone. Rinse the turn around cup's interior surface with acetone into the jar labelled "2 in. filter front-half rinse." Rinse the exterior surface of the turn around cup and the remaining interior surface of the top into the jar labelled "nozzle and cyclone rinse."

4.7.5 Disassemble the cyclone and rinse the inside of the cyclone and the nozzle with acetone into the jar labelled "nozzle and cyclone rinse." Any particulate inside the bowl goes into the nozzle and cyclone rinse jar.

4.7.6 Disassemble the 2 inch filter holder. Clean-up the filter dry into the jar labelled "2 in. filter." If

Teflon tape was used on the threads, be careful not to include any with the catch.

4.7.7 Rinse the front half of the of the 2 inch filter holder and the interior of the cyclone exit tube with acetone into the jar labelled "2 in. filter front half rinse".

5. ANALYSIS.

5.1 Laboratory Analysis Procedure.

5.1.1 Determine the non-PM_{10} catch gravimetrically from the nozzle/cyclone rinse.

5.1.2 Determine the PM_{10} catch from the 2" filter.

5.1.3 Determine the PM_{10} catch from the front half rinse and add it to the filter catch to obtain the total PM_{10} catch.

6. CALIBRATION.

6.1 Pitot Tube, Metering System, Probe Heater, Temperatu Gauges, Leak-check of Metering System, and Barometer. Same as in Method 5, Sections 5.1 through 5.7 respectively.

6.2 Cyclone and Nozzle Combination. Meets design specifications - no calibration necessary.

7. CALCULATIONS.

7.1 Pre-test Calculations.

7.1.1 Absolute Pressure, P_s

$$P_s = P_{bar} + P_g/13.6$$

P_s = Stack Absolute Pressure [in. Hg]
P_g = Stack Static Pressure [in. H_2O]
P_{bar} = Ambient Barometric Pressure [in. H_2O]

7.1.2 Molecular Weight, M_w

$$M_w = M_d(1-B_w) + 18B_w$$

M_w = Molecular Weight of Stack Gas, wet basis [lb/lb-mole]
M_d = Molecular Weight of Stack Gas, dry basis = $.44(\%CO_2) + .32(\%O_2) + .28(\%N_2 + \%CO)$

[use 29 lb/lb-mole]
B_w = Fraction Moisture Content [fraction H_2O]

7.1.3 Average Velocity Head, ΔP_{avg}

$$\Delta P_{avg} = \sum[(\Delta P_i)^{0.5}]^2/n$$

ΔP_{avg} = Average Velocity Head [in. H_2O]
ΔP_i = Velocity Head at i^{th} Traverse Point [in. H_2O]
n = number of traverse points

7.1.4 Viscosity, μ

$$\mu - 152.4 + 0.255t_s + (0.00569t_s)^2 + 0.5315(\%O_2) - 74.14B_w$$

μ = Viscosity [micropoise]
t_s = Average Stack Temperature [°F]
B_w = Fraction Moisture Content [fraction H_2O]

7.1.5 Cyclone Flow Rate, Q_c

$$Q_c = 0.002837\mu[(t_s + 460)/M_wP_s]^{0.2949}$$

Q_c = Cyclone Flow Rate [ft^3/min (ACFM)]
μ = Viscosity [micropoise]
t_s = Average Stack Temperature [°F]
M_w = Molecular Weight, wet basis [lb/lb-mole]
P_s = Stack Absolute Pressure [in. H_2O]

7.1.6 Desired Nozzle Diameter, D_{nd}

$$D_{nd} = 0.206Q_c^{0.5}[(P_s)(M_w)/(t_s + 460)(\Delta P_{avg})]^{0.25}$$

D_{nd} = Desired Nozzle Diameter [in.]
Q_c = Cyclone Flow Rate [ACFM]
P_s = Stack Absolute Pressure [in. Hg]
M_w = Molecular Weight, wet basis [lb/lb-mole]
t_s = Average Stack Temperature [°F]
ΔP_{avg} = Average Velocity Head [in. H_2O]

7.1.7 Average Stack Gas Velocity, v_s

$$v_s = (85.48)(C_p)[(t_s + 460)(\Delta P_{avg})/(P_s)(M_w)]$$

v_s = Average Stack Gas Velocity, [ft/sec]
C_p = Pitot Coefficient [Use .84 for S-Type Pitot]
t_s = Average Stack Temperature [°F]
ΔP_{avg} = Average Velocity Head [in. H_2O]
P_s = Stack Absolute Pressure [in. Hg]
M_w = Molecular Weight, wet basis [lb/lb-mole]

7.1.8 Orifice Pressure Head Required, ΔH

$$\Delta H = [(Q_c)(1-B_w)(P_s)/(t_s+460)]^2 *[(t_m+460)(M_d)(1.083)(\Delta H_@)/(P_{bar})]$$

ΔH = Orifice Pressure Head [in. H_2O]
Q_c = Cyclone Flow Rate [ACFM]
B_w = Fraction Moisture Content [fraction H_2O]
P_s = Stack Absolute Pressure [in. Hg]
t_s = Average Stack Temperature [°F]
t_m = Meter Box Temperature [°F]
M_d = Molecular Weight, dry basis [29 lb/lb-mole]
$\Delta H_@$ = Orifice Pressure Head @ 0.75 cfm [in. H_2O]
P_{bar} = Ambient Barometric Pressure [in. Hg]

→ Solve for t_s, t_s + 50°F, and t_s - 50°F.

7.1.9 Nozzle Velocity, v_n

$$v_n = (3.056)(Q_c)/(Dia)^2$$

v_n = Nozzle Velocity [ft/s]
Q_c = Cyclone Flow Rate [ACFM]
Dia = Diameter of nozzle [in]

→ Solve for the two nozzles closest to D_{nd}

7.1.10 Percent Isokinetic, I

$$I = (100)(v_n)/v_s$$

I = Percent Isokinetic [%]
v_n = Nozzle Velocity [ft/s]
v_s = Average Stack Gas Velocity [ft/s]

→ Solve for each of the two nozzles

7.1.11 Minimum Velocity, v_{min}

First, calculate R_{min}:

$$R_{min} = 0.2457 + [0.3072 - (0.2603)(Q_c)^{0.5}(\mu)/(v_n)^{1.5}]^{0.5}$$

If R_{min} < 0.5 or is an imaginary number,
→ use Equation 1.
Otherwise use Equation 2.

1. $v_{min} = v_n(0.5)$
2. $v_{min} = v_n(R_{min})$

R_{min} = Interim Value

v_{min} = Minimum Velocity [ft/s]
v_n = Nozzle Velocity [ft/s]
Q_c = Cyclone Flow Rate [ft^3/min (ACFM)]
μ = Viscosity [micropoise]

→ Solve for each of the two nozzles

7.1.12 Minimum Velocity Head, ΔP_{min}

$$\Delta P_{min} = 1.3686/10000[(P_s)(M_w)/(t_s+460)][(v_{min})(C_p)]^2$$

ΔP_{min} = Minimum Velocity Head [in. H_2O]
P_s = Stack Absolute Pressure [in. Hg]
M_w = Molecular Weight of Stack Gas, wet basis [lb/lb-mole]
t_s = Average Stack Temperature [°F]
v_{min} = Minimum Velocity [ft/s]
C_p = Pitot Coefficient [Use .84]

→ Solve for each of the two nozzles

7.1.13 Maximum Velocity, v_{max}

First, calculate R_{max}:

$$R_{max} = 0.4457 + [0.5690 + (0.2603)(Q_c)^{0.5}(\mu)/(v_n)^{1.5}]^{0.5}$$

If $R_{max} > 1.5$, use Equation 1.
Otherwise, use Equation 2.

1 $v_{max} = v_n(1.5)$
2. $v_{max} = v_n(R_{max})$

R_{max} = Interim Value
v_{max} = Maximum Velocity [ft/s]
v_n = Nozzle Velocity [ft/s]
Q_c = Cyclone Flow Rate [ft^3/min (ACFM)]
μ = Viscosity [micropoise]

→ Solve for each of the two nozzles

7.1.14 Maximum Velocity Head, ΔP_{max}

$$\Delta P_{max} = 1.3686/10000[(P_s)(M_w)/(t_s+460)][(v_{max})(C_p)]^2$$

ΔP_{max} = Maximum Velocity Head [in. H_2O]
P_s = Stack Absolute Pressure [in. Hg]
M_w = Molecular Weight of Stack Gas, wet basis [lb/lb-mole]
t_s = Average Stack Temperature [°F]
v_{max} = Maximum Velocity [ft/s]

C_p = Pitot Coefficient [Use .84]

→ Solve for each of the two nozzles

7.1.15 Dwell Time for First Traverse Point, θ_1

$$\theta_1 = [\Delta P'_1/\Delta P'_{avg}]^{0.5}[\theta_{tot}/n]$$

θ_1 = Dwell Time, First Traverse Point [min]
$\Delta P'_1$ = Velocity Head at First Point [in. H_2O] (from pre-test traverse)
$\Delta P'_{avg}$ = Average Velocity Head [in. H_2O]
θ_{tot} = Total Run Time [min]
n = Number of Traverse Points [should be 12 pts.]

→ Round Dwell Time to the nearest 15 seconds.

7.1.16 Dwell Time for Subsequent Points, θ_n

$$\theta_n = \theta_1[\Delta P'_1/\Delta P'_n]^{0.5} \qquad n = \{2,3,4,...12\}$$

θ_n = Dwell Time on Traverse Point n [minutes]
n = Number of Subsequent Points [points 2 through 12]
θ_1 = Dwell Time, First Traverse Point [minutes]
$\Delta P'_n$ = Velocity Head at Traverse Point n [in. H_2O]
$\Delta P'_{avg}$ = Average Velocity Head [in. H_2O]

→ Round Dwell Times to the nearest 15 seconds.

7.2 Post-test Calculations.

NOTE: Use values from the actual test conditions with the exceptions of the ΔP and the T_s which are to be taken from the preliminary traverse.

7.2.1 Stack Gas Viscosity, μ_s

$$\mu_s = C_1 + C_2T_s + C_3T_s^2 + C_4fO_2 - C_6B_{ws}$$

μ_s = Stack Gas Viscosity [micropoise]
C_1 = 51.05 micropoise
C_2 = 0.207 micropoise/°R
C_3 = 3.24×10^{-5} micropoise/°R^2
C_4 = 53.147 micropoise/fraction O_2
C_6 = 74.143 micropoise/fraction H_2O
T_s = Average Absolute Stack Temperature [°R]
f_{O2} = Stack Gas Fraction O_2 by volume, dry basis
B_{ws} = Moisture Fraction of Stack Gas [fraction O_2]

7.2.2 PM_{10} Flow Rate, Q_s

$$Q_s = [T_s/K_1P_s][Q_{s(std)} + V_{W(std)}/\theta]$$

Q_s = Total Cyclone Flow Rate [ft^3/min] (at wet cyclone conditions)
T_s = Average Absolute Stack Temperature [°R]
K_1 = Constant [17.64 °R / in. Hg]
P_s = Absolute Stack Pressure [in. Hg]
$Q_{s(std)}$ = Total Cyclone Flow Rate [dscf/min] (at standard conditions)
$V_{W(std)}$ = Volume of Water Vapor in Gas Sample [scf] (at standard conditions)
θ = Total Sampling Time [minutes]

7.2.3 **Molecular Weight of Stack Gas, M_W**

$$M_W = M_d(1-B_{WS}) + 18.0(B_{WS})$$

M_W = Molecular Weight of Stack Gas [lb/lb-mole] (Wet Basis)

M_d = Molecular Weight of Stack Gas [lb/lb-mole] (Dry Basis)
B_{WS} = Moisture Fraction of Stack Gas [fraction O_2]

7.2.4 **Aerodynamic Cut Size, D_{50}**

$$D_{50} = \beta[(t_s+460)/(M_w)(P_s)]^{0.2091}[(\mu_s)/(Q_s)]^{0.7091}$$

D_{50} = Aerodynamic Cut Size [μm]
β = Constant [0.15625 for English units]
t_s = Average Stack Temperature [°F]
M_w = Molecular Weight of Stack Gas, wet basis [lb/lb-mole]
P_s = Stack Absolute Pressure [in. Hg]

7.2.5 **Percent Isokinetic, I,**

$$I = 100(t_s+460)V_{m(std)}P_{(std)}/60(T_{(std)})v_s\theta A_n P_s(1-B_w)$$

I = Percent Isokinetic [%]
t_s = Average Stack Temperature [°F]
V_m = Volume of Gas Metered [dscf]
$P_{(std)}$ = Standard Pressure [29.92 in. Hg]
$T_{(std)}$ = Temperature Standard [537 °R]
v_s = Average Stack Velocity [ft/sec]
θ = Total Run Time [minutes]
A_n = Nozzle Area [ft^2] = $(\pi/144)(D_n/2)^2$
D_n = Nozzle Diameter [in.]
P_s = Stack Absolute Pressure [in. Hg]
B_w = Fraction Moisture Content [fraction H_2O]

7.3 Acceptable Results. The results are acceptable it the following two conditions are met:

7.2.1 The aerodynamic cut size, D_{50}, must be between 9.0µ and 11.0µm (9.0µm ≤ D_{50} ≤ 11.0µm).

7.2.2 No sampling points are outside of ΔP_{min} and ΔP_{max} O the isokinetic rate, I, is between 80% and 120 (80% ≤ I ≤ 120%) and no more than one sampling poin is outside of ΔP_{min} and ΔP_{max}.

8. QUALITY CONTROL.

8.1 Visual Inspection. Examine the Pitots, nozzle, cyclone, an filter holder prior to testing for any visible signs o damage or wear.

8.2 On-site dry gas meter audit. Prior to testing preform an on site dry gas meter audit to check the calibration values o the volume metering system. This is the usual 10 minut audit for any meter box (See section 10.4).

9.0 DIAGRAMS.

CYCLONE DIAGRAM

10.0 DATA SHEETS

10.1 Sampling and Velocity Traverse Point Determination
EPA Method 1

10.2 Air Flow Rate Determinations
EPA Method 2

10.3 Field Test Log.

10.4 On-site Dry Gas Meter Audit.

10.5 Sampling Equipment Calibration Checklist.

10.6 Method 201A (PM-10) Field Data Sheet.

Sampling and Velocity Traverse Point Determination
EPA Method 1

PLANT NAME ______________________
CITY, STATE ______________________
SAMPLING LOCATION ______________________

NO. OF PORTS AVAILABLE ______________
NO. OF PORTS USED ______________
PORT INSIDE DIAMETER ______________

DISTANCE FROM FAR WALL TO OUTSIDE OF PORT ________
NIPPLE LENGTH AND/OR WALL THICKNESS ________
DEPTH OF STACK OR DUCT ________
STACK OR DUCT WIDTH (IF RECTANGULAR) ________

EQUIVALENT DIAMETER:

$D_E = \frac{2 \times DEPTH \times WIDTH}{DEPTH + WIDTH} = \frac{2(\quad)(\quad)}{(\quad + \quad)} =$ ________

DISTANCE FROM PORTS TO FLOW DISTURBANCES	UPSTREAM	DOWNSTREAM
	________	________
DIAMETERS	________	________

STACK/DUCT AREA = ________ = ________ IN²

LOCATION OF POINTS IN CIRCULAR STACKS OR DUCTS

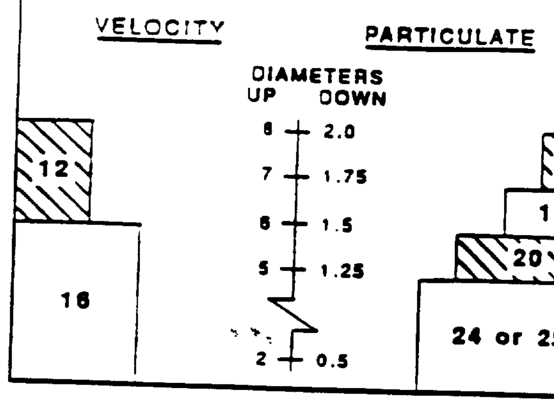
	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.5	81.2	75.0	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77.0
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											98.9

LOCATION OF POINTS IN RECTANGULAR STACKS OR DUCTS

	2	3	4	5	6	7	8	9	10	11	12
1	25.0	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2
2	75.0	50.0	37.5	30.0	25.0	21.4	18.8	16.7	15.0	13.6	12.5
3		83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8
4			87.5	70.0	58.3	50.0	43.8	38.9	35.0	31.8	29.2
5				90.0	75.0	64.3	56.3	50.0	45.0	40.9	37.5
6					91.7	78.6	68.8	61.1	55.0	50.0	45.8
7						92.9	81.3	72.2	65.0	59.1	54.2
8							93.8	83.3	75.0	68.2	62.5
9								94.4	85.0	77.3	70.8
10									95.0	86.4	79.2
11										95.5	87.5
12											95.8

DRAW HORIZONTAL LINE THROUGH DIAMET

If more than 8 and 2 diameters and if du dia. is less than 24", use 8 or 9 points.



POINT	% OF DUCT DEPTH	DISTANCE FROM INSIDE WALL	DISTANCE FROM OUTSI OF PORT
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

SEE REVERSE FOR FIELD USE CHECKLIS

F-0016
10-90

ENTROPY

AIR FLOW RATE DETERMINATIONS

Plant Name ______________________ Run No. __________

City/State ______________________ Date __________

Test Location ______________________ Personnel __________

Barometric Pres. (Pbar) __________ In. Hg Static Pres. (Pg) __________ In. H_2O

Pitot ID __________ Pitot Coeff. (Cp) ______ Pressure Gauge Set ID __________

Thermocouple ID __________ Duct Length/Diameter __________ Width __________
--Specify inches (") or feet (')--

VELOCITY TRAVERSES
Start-Finish Times: ________ - ________

Point No.	Δ P In. H_2O	Temp. °F
Avg.*		

ORSAT DATA

Sampling Time	Analysis Time	CO_2 (A) Reading	O_2 (B) Reading	%O_2 (B-A)	%CO+N_2 (100-B)
	Average				

Bag No. __________ Pump __________

FYRITE DATA, % CO_2				

MOISTURE DATA (WET BULB/DRY BULB)

Port	Time	Dry Bulb °F	Wet Bulb °F	Diff.	% H_2O

MOISTURE DATA (STOICHIOMETRIC)

Free Water in Fuel, %		
Water from Fuel Combustion, %		
Ambient Water, %		
Relative Humidity, %		
Ambient Temperature, °F		
Total %		

VOLUMETRIC AIR FLOW RATES

Dry at Standard Conditions, Qsd =	SCFM
Wet at Stack Conditions, Qaw =	ACFM

ADDITIONAL DATA

*Δ P average is square of average square root.

See page 2 for field flow rate calculatio

FIELD TEST LOG

Plant Name ______________________________ Job No. __________

Sampling Location ______________________________

Start | Stop | Comments/Problems* | Run No. ______ | Date ______

Sampling Team Initials ______(Team Leader) ______________________(Others)

Posttest Leak Rate ______ Sample Appearance ______________________

Good Run (check)? ___YES ___NO (if NO, explain in "Comments/Problems")

Start | Stop | Comments/Problems* | Run No. ______ | Date ______

Sampling Team Initials ______(Team Leader) ______________________(Others)

Posttest Leak Rate ______ Sample Appearance ______________________

Good Run (check)? ___YES ___NO (if NO, explain in "Comments/Problems")

Start | Stop | Comments/Problems* | Run No. ______ | Date ______

Sampling Team Initials ______(Team Leader) ______________________(Others)

Posttest Leak Rate ______ Sample Appearance ______________________

Good Run (check)? ___YES ___NO (if NO, explain in "Comments/Problems")

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* USE REVERSE SIDE IF MORE SPACE REQUIRED.

ENTROPY

ON-SITE DRY GAS METER AUDIT

Plant Name ______________________________ Job Number __________

Date ________________ Meterbox Identification Number __________

Time ________________ Fulltest Gamma (Y) ________ $\Delta H_@$ ________

Auditor ________________ Barometric Pressure (P_{bar}) ____________ In. H

As Applicable:

Zero Magnehelics? (check) ____

Zero/Level Manometer? (check) ____

Dry Gas Meter Reading (ft^3)	Meter Temperature (°F)	Upper and Lower Limits for Audit Gamma
Final ____________	Final ____________	0.96 * Y = ____________
Initial ____________	Initial ____________	1.04 * Y = ____________

Dry Gas Volume Metered (ft^3)	Average Meter Temperature (°F)	Run Time (Base = 10)	
		(Minutes)	(Seconds)
Vm = ____________	Tm = ____________	________	________

$$Y_c = \frac{[\text{Min.} + (\text{Sec.} / 60)]}{Vm} * \left[\frac{0.0319\ (Tm + 460)}{P_{bar}}\right]^{0.5}$$

$$Y_c = \frac{[\_\_\_\_ + (\_\_\_\_ / 60)]}{\_\_\_\_\_\_} * \left[\frac{0.0319\ (\_\_\_\_ + 460)}{\_\_\_\_\_\_}\right]^{0.5} = \frac{\_\_\_\_\_\_\_\_}{\text{Calculated Audit Y}}$$

Audit Gamma Within Acceptable Limits? Yes ____ No ____

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ENTROPY

SAMPLING EQUIPMENT CHECKLIST

Plant Name/Address ______________________ Job No. ______

Sampling Location ______________________ Team Leader ______

BAROMETER CHECK

Date	Entropy In-House Reference Barometer	Field Barometer	Check OK?*

* ± 0.1" Mercury

THERMOMETERS AND THERMOCOUPLE CHECK

Date ______ | Reference Thermometer Ambient Temperature, °F ______

Thermometers	Ambient Temperature, °F	Acceptance Range, °F	Check OK?
Impinger Exit		± 2.0	
Filter Box		± 5.4	
Dry Gas Meter		± 5.4	

Adjust thermometer until acceptable. If it cannot be adjusted, use as back-up. If no backup, record ambient temp. indicated by unadjusted thermometer.

Thermocouples		Acceptance Range	Check OK?
		± 8.0* (± 2.0)**	

* ± 1.5% of Absolute Temperature.
** Acceptance range is ± 2.0°F if used in saturated or water droplet-laden gas stream.

PITOT AND NOZZLE CHECK

Pitot No.	Visual Check	Nozzle No.	Visual Check

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ENTROPY

METHOD 201A (PM-10) FIELD DATA

Plant Name ______________ Run Number ______
City/State ______________ Time Start ______
Sampling Location ______________ Time Stop ______
Date ______ Team Leader ______ Techs ______ Job Number ______
*Train Leak Check Vacuum, In. Hg ____ ____ ____ ____ Barometric Pressure, In. Hg ______
Train Leak Rate, Cubic Ft./Min. ____ ____ ____ ____ Static Pressure, In. H_2O ______

EQUIPMENT CHECKS

____ Pitot, Pretest
____ Pitot, Posttest
____ H3 Sampling Sys/Ted Bag
____ Thermocouple @ ____ Pre
____ Thermocouple @ ____ Post

IDENTIFICATION NUMBERS

Meterbox ______ Meterbox Gamma ______ Reagent Box ______
T/C Readout ______ T/C Probe ______ Umbilical ______
Sampling Box ______ Orsat Pump ______ Tedlar Bag ______
Nozzle(s) Actually Used: Pitot ______
No. ______ Diameter ______ No. ______ Diameter ______

FILTER NO.	TARE

Est % H_2O ______

Delta $H_@$ ______
Delta H_t ______
Delta H_{t+50} ______
Delta H_{t-50} ______
Delta P_{avg} ______
Meter Temp. ______
Stack Temp. ______

NOZZLE SELECTION CRITERIA

Desired Dia. ______

	Nozzle 1	Nozzle 2
Diameter		
Nozzle Number		
Delta P_{min}		
Delta P_{max}		

FYRITE

______
______
______
______

C_p ______

	Sample Point	Dwell Time Minutes	Elapsed Time Minutes	Dry Gas Meter Readings Cubic Feet	Pitot Reading In. H_2O	Orifice Setting In. H_2O	Gas Meter Temp °F	Vacuum Gauge In. Hg	Gas Temps Filter Box °F	Gas Temps Imping Exit °F	Cyclone Temp. °F	Stack Temp. °F
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

* [illegible] VE HEAD BEFORE

ENTROPY

Emission Gas Recycle, Data Reduction, Version 3.4 MAY 1988

Test ID. Code: Chapel Hill 2.
Test Location: Baghouse Outlet.
Test Site: Chapel Hill.
Test Date: 10/20/86.
Operator(s): JB RH MH.

Entered Run Data

Temperatures:

T(STK)	251.0 F
T(RCL)	259.0 F
T(LFE)	81.0 F
T(DGM)	78.0 F

System Pressures:

DH(ORI)	1.18 INWG
DP(TOT)	1.91 INWG
P(INL)	12.15 INWG
DP(RCL)	2.21 INWG
DP(PTO)	0.08 INWG

Miscellaneous:

P(BAR)	29.90 INWG

Entered Run Data—Continued

DP(STK)	0.10 INWG
V(DGM)	13.744 FT3
TIME	60.00 MIN
% CO2	3.00
% O2	20.00
NOZ (IN)	0.2500

Water Content:

Estimate	0.0%
or	
Condenser	7.0 ML
Column	0.0 GM

Raw Masses:

Cyclone 1	21.7 MG
Filter	11.7 MG
Impinger Residue	0.0 MG

Blank Values:

CYC Rinse	0.0 MG
Filter Holder Rinse	0.0 MG
Filter Blank	0.0 MG
Impinger Rinse	0.0 MG

Calibration Values:

CP(PITOT)	0
DH@(ORI)	10.
M(TOT LFE)	0.
B(TOT LFE)	–
M(RCL LFE)	0.
B(RCL LFE)	–
DGM GAMMA	0.

Reduced Data

Stack Velocity (FT/SEC)	15.
Stack Gas Moisture (%)	2.
Sample Flow Rate (ACFM)	0.
Total Flow Rate (ACFM)	0.
Recycle Flow Rate (ACFM)	0.
Percent Recycle	48.
Isokinetic Ratio (%)	95.

	(Particulate) (UM)	(% <)	(MG/DNCM)	(GR/ACF)	(GR/DCF)	(LB/DSCF) (1E6)
Cyclone 1	10.15	35.8	56.6	0.01794	0.02470	3.53
Backup Filter			30.5	0.00968	0.01332	1.90
Particulate Total			87.2	0.02762	0.03802	5.44

Note: Figure 14. Example inputs and outputs of the EGR reduction program.

Method 201A—Determination of PM₁₀ Emissions (Constant Sampling Rate Procedure)

1. Applicability and Principle

1.1 Applicability. This method applies to the in-stack measurement of particulate matter (PM) emissions equal to or less than an aerodynamic diameter of nominally 10 (PM₁₀) from stationary sources. The EPA recognizes that condensible emissions not collected by an in-stack method are also PM₁₀, and that emissions that contribute to ambient PM₁₀ levels are the sum of condensible emissions and emissions measured by an in-stack PM₁₀ method, such as this method or Method 201. Therefore, for establishing source contributions to ambient levels of PM₁₀, such as for emission inventory purposes, EPA suggests that source PM₁₀ measurement include both in-stack PM₁₀ and condensible emissions. Condensible emissions may be measured by an impinger analysis in combination with this method.

1.2 Principle. A gas sample is extracted at a constant flow rate through an in-stack sizing device, which separates PM greater than PM₁₀. Variations from isokinetic sampling conditions are maintained within well-defined limits. The particulate mass is determined gravimetrically after removal of uncombined water.

2. Apparatus

Note: Methods cited in this method are part of 40 CFR part 60, appendix A.

2.1 Sampling Train. A schematic of the Method 201A sampling train is shown in Figure 1 of this method. With the exception of the PM₁₀ sizing device and in-stack filter, this train is the same as an EPA Method 17 train.

2.1.1 Nozzle. Stainless steel (316 or equivalent) with a sharp tapered leading edge. Eleven nozzles that meet the design specification in Figure 2 of this method are recommended. A larger number of nozzles with small nozzle increments increase the likelihood that a single nozzle can be used for the entire traverse. If the nozzles do not meet the design specifications in Figure 2 of this method, then the nozzles must meet the criteria in Section 5.2 of this method.

2.1.2 PM₁₀ Sizer. Stainless steel (316 or equivalent), capable of determining the PM₁₀ fraction. The sizing device shall be either a cyclone that meets the specifications in Section 5.2 of this method or a cascade impactor that has been calibrated using the procedure in Section 5.4 of this method.

2.1.3 Filter Holder. 63-mm, stainless steel. An Andersen filter, part number SE274, has been found to be acceptable for the in-stack filter. Note: Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

2.1.4 Pitot Tube. Same as in Method 5, Section 2.1.3. The pitot lines shall be made of heat resistant tubing and attached to the probe with stainless steel fittings.

2.1.5 Probe Liner. Optional, same as in Method 5, Section 2.1.2.

2.1.6 Differential Pressure Gauge, Condenser, Metering System, Barometer, and Gas Density Determination Equipment. Same as in Method 5, Sections 2.1.4, and 2.1.7 through 2.1.10, respectively.

2.2 Sample Recovery.

2.2.1 Nozzle, Sizing Device, Probe, and Filter Holder Brushes. Nylon bristle brushes with stainless steel wire shafts and handles, properly sized and shaped for cleaning the nozzle, sizing dedvice, probe or probe liner, and filter holders.

2.2.2 Wash Bottles, Glass Sample Storage Containers, Petri Dishes, Graduated Cylinder and Balance, Plastic Storage Containers, Funnel and Rubber Policeman, and Funnel. Same as in Method 5, Sections 2.2.2 through 2.2.8, respectively.

2.3 Analysis. Same as in Method 5, Section 2.3.

3. Reagents

The reagents for sampling, sample recovery, and analysis are the same as that specified in Method 5, Sections 3.1, 3.2, and 3.3, respectively.

4. Procedure

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation. Same as in Method 5, Section 4.1.1.

4.1.2 Preliminary Determinations. Same as in Method 5, Section 4.1.2, except use the directions on nozzle size selection and sampling time in this method. Use of any nozzle greater than 0.16 in. in diameter require a sampling port diameter of 6 inches. Also, the required maximum number of traverse points at any location shall be 12.

4.1.2.1 The sizing device must be in-stack or maintained at stack temperature during sampling. The blockage effect of the CSR sampling assembly will be minimal if the cross-sectional area of the sampling assembly is 3 percent or less of the cross-sectional area of the duct. If the cross-sectional area of the assembly is greater than 3 percent of the cross-sectional area of the duct, then either determine the pitot coefficient at sampling conditions or use a standard pitot with a known coefficient in a configuration with the CSR sampling assembly such that flow disturbances are minimized.

4.1.2.2 The setup calculations can be performed by using the following procedures.

4.1.2.2.1 In order to maintain a cut size of 10 μm in the sizing device, the flow rate through the sizing device must be maintained at a constant, discrete value during the run. If the sizing device is a cyclone that meets the design specifications in Figure 3 of this method, use the equations in Figure 4 of this method to calculate three orifice heads (ΔH): one at the average stack temperature, and the other two at temperatures ±28 °C (±50 °F) of the average stack temperature. Use ΔH calculated at the average stack temperature as the pressure head for the sample flow rate as long as the stack temperature during the run is within 28 °C (50 °F) of the average stack temperature. If the stack temperature varies by more than 28 °C (50 °F), then use the appropriate ΔH.

4.1.2.2.2 If the sizing device is a cyclone that does not meet the design specifications in Figure 3 of this method, use the equations in Figure 4 of this method, except use the procedures in Section 5.3 of this method to determine Q_s, the correct cyclone flow rate for a 10 μm size.

4.1.2.2.3 To select a nozzle, use the equations in Figure 5 of this method to calculate Δp_{min} and Δp_{max} for each nozzle at all three temperatures. If the sizing device is a cyclone that does not meet the design specifications in Figure 3 of this method, the example worksheets can be used.

4.1.2.2.4 Correct the Method 2 pitot readings to Method 201A pitot readings by multiplying the Method 2 pitot readings by the square of a ratio of the Method 201A pitot coefficient to the Method 2 pitot coefficient. Select the nozzle for which Δp_{min} and Δp_{max} bracket all of the corrected Method 2 pitot readings. If more than one nozzle meets this requirement, select the nozzle giving the greatest symmetry. Note that if the expected pitot reading for one or more points is near a limit for a chosen nozzle, it may be outside the limits at the time of the run.

4.1.2.2.5 Vary the dwell time, or sampling time, at each traverse point proportionately with the point velocity. Use the equations in Figure 6 of this method to calculate the dwell time at the first point and at each subsequent point. It is recommended that the number of minutes sampled at each point be rounded to the nearest 15 seconds.

4.1.3 Preparation of Collection Train. Same as in Method 5, Section 4.1.3, except omit directions about a glass cyclone.

4.1.4 Leak-Check Procedure. The sizing device is removed before the post-test leak-check to prevent any disturbance of the collected sample prior to analysis.

4.1.4.1 Pretest Leak-Check. A pretest leak-check of the entire sampling train, including the sizing device, is required. Use the leak-check procedure in Method 5, Section 4.1.4.1 to conduct a pretest leak-check.

4.1.4.2 Leak-Checks During Sample Run. Same as in Method 5, Section 4.1.4.1.

4.1.4.3 Post-Test Leak-Check. A leak-check is required at the conclusion of each sampling run. Remove the cyclone before the leak-check to prevent the vacuum created by the cooling of the probe from disturbing the collected sample and use the procedure in Method 5, Section 4.1.4.3 to conduct a post-test leak-check.

4.1.5 Method 201A Train Operation. Same as in Method 5, Section 4.1.5, except use the procedures in this section for isokinetic sampling and flow rate adjustment. Maintain the flow rate calculated in Section 4.1.2.2.1 of this method throughout the run provided the stack temperature is within 28 °C (50 °F) of the temperature used to calculate ΔH. If stack temperatures vary by more than 28 °C (50 °F), use the appropriate ΔH value calculated in Section 4.1.2.2.1 of this method. Calculate the dwell time at each traverse point as in Figure 6 of this method.

4.1.6 Calculation of Percent Isokinetic Rate and Aerodynamic Cut Size (D_{50}). Calculate percent isokinetic rate and D_{50} (see Calculations, Section 6 of this method) to determine whether the test was valid or another test run should be made. If there was difficulty in maintaining isokinetic sampling rates within the prescribed range, or if the D_{50} is not in its proper range because of source conditions, the Administrator may be consulted for possible variance.

4.2 Sample Recovery. If a cascade impactor is used, use the manufacturer's recommended procedures for sample recovery. If a cyclone is used, use the same sample recovery as that in Method 5, Section 4.2, except an increased number of sample recovery containers is required.

4.2.1 *Container Number 1* (In-Stack Filter). The recovery shall be the same as that for Container Number 1 in Method 5, Section 4.2.

4.2.3 *Container Number 2* (Cyclone or Large PM Catch). This step is optional. The anisokinetic error for the cyclone PM is theoretically larger than the error for the PM_{10} catch. Therefore, adding all the fractions to get a total PM catch is not as accurate as Method 5 or Method 201. Disassemble the cyclone and remove the nozzle to recover the large PM catch. Quantitatively recover the PM from the interior surfaces of the nozzle and cyclone, excluding the "turn around" cup and the interior surfaces of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.4 *Container Number 3* (PM_{10}). Quantitatively recover the PM from all of the surfaces from the cyclone exit to the front half of the in-stack filter holder, including the "turn around" cup inside the cyclone and the interior surfaces of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.6 *Container Number 4* (Silica Gel). The recovery shall be the same as that for Container Number 3 in Method 5, Section 4.2.

4.2.7 *Impinger Water*. Same as in Method 5, Section 4.2, under "Impinger Water."

4.3 Analysis. Same as in Method 5, Section 4.3, except handle Method 201A Container Number 1 like Container Number 1, Method 201A Container Numbers 2 and 3 like Container Number 2, and Method 201A Container Number 4 like Container Number 3. Use Figure 7 of this method to record the weights of PM collected. Use Figure 5–3 in Method 5, Section 4.3, to record the volume of water collected.

4.4 Quality Control Procedures. Same as in Method 5, Section 4.4.

5. *Calibration*

Maintain an accurate laboratory log of all calibrations.

5.1 Probe Nozzle, Pitot Tube, Metering System, Probe Heater Calibration, Temperature Gauges, Leak-check of Metering System, and Barometer. Same as in Method 5, Section 5.1 through 5.7, respectively.

5.2 Probe Cyclone and Nozzle Combinations. The probe cyclone and nozzle combinations need not be calibrated if both meet design specifications in Figures 2 and 3 of this method. If the nozzles do not meet design specifications, then test the cyclone and nozzle combinations for conformity with performance specifications (PS's) in Table 1 of this method. If the cyclone does not meet design specifications, then the cyclone and nozzle combination shall conform to the PS's and calibrate the cyclone to determine the relationship between flow rate, gas viscosity, and gas density. Use the procedures in Section 5.2 of this method to conduct PS tests and the procedures in Section 5.3 of this method to calibrate the cyclone. The purpose of the PS tests are to conform that the cyclone and nozzle combination has the desired sharpness of cut. Conduct the PS tests in a wind tunnel described in Section 5.2.1 of this method and particle generation system described in Section 5.2.2 of this method. Use five particle sizes and three wind velocities as listed in Table 2 of this method. A minimum of three replicate measurements of collection efficiency shall be performed for each of the 15 conditions listed, for a minimum of 45 measurements.

5.2.1 Wind Tunnel. Perform the calibration and PS tests in a wind tunnel (or equivalent test apparatus) capable of establishing and maintaining the required gas stream velocities within 10 percent.

5.2.2 Particle Generation System. The particle generation system shall be capable of producing solid monodispersed dye particles with the mass median aerodynamic diameters specified in Table 2 of this method. Perform the particle size distribution verification on an integrated sample obtained during the sampling period of each test. An acceptable alternative is to verify the size distribution of samples obtained before and after each test, with both samples required to meet the diameter and monodispersity requirements for an acceptable test run.

5.2.2.1 Establish the size of the solid dye particles delivered to the test section of the wind tunnel by using the operating parameters of the particle generation system, and verify them during the tests by microscopic examination of samples of the particles collected on a membrane filter. The particle size, as established by the operating parameters of the generation system, shall be within the tolerance specified in Table 2 of this method. The precision of the particle size verification technique shall be at least ±0.5 μm, and particle size determined by the verification technique shall not differ by more than 10 percent from that established by the operating parameters of the particle generation system.

5.2.2.2 Certify the monodispersity of the particles for each test either by microscopic inspection of collected particles on filters or by other suitable monitoring techniques such as an optical particle counter followed by a multichannel pulse height analyzer. If the proportion of multiplets and satellites in an aerosol exceeds 10 percent by mass, the particle generation system is unacceptable for the purpose of this test. Multiplets are particles that are agglomerated, and satellites are particles that are smaller than the specified size range.

5.2.3 Schematic Drawings. Schematic drawings of the wind tunnel and blower system and other information showing complete procedural details of the test atmosphere generation, verification, and delivery techniques shall be furnished with calibration data to the reviewing agency.

5.2.4 Flow Measurements. Measure the cyclone air flow rates with a dry gas meter and a stopwatch, or a calibrated orifice system capable of measuring flow rates to within 2 percent.

5.2.5 Performance Specification Procedure. Establish test particle generator operation and verify particle size microscopically. If monodispersity is to be verified by measurements at the beginning and the end of the run rather than by an integrated sample, these measurements may be made at this time.

5.2.5.1 The cyclone cut size, or D_{50}, of a cyclone is defined here as the particle size having a 50 percent probability of penetration. Determine the cyclone flow rate at which D_{50} is 10 µm. A suggested procedure is to vary the cyclone flow rate while keeping a constant particle size of 10 µm. Measure the PM collected in the cyclone (m_c), the exit tube (m_t), and the filter (m_f). Calculate cyclone efficiency (E_c) for each flow rate as follows:

$$E_c = \frac{m_c}{(m_c + m_t + m_f)} \times 100$$

5.2.5.2 Do three replicates and calculate the average cyclone efficiency ($E_{c(avg)}$) as follows:

$$E_{c(avg)} = (E_1 + E_2 + E_3)/3$$

Where E_1, E_2, and E_3 are replicate measurements of E_c.

5.2.5.3 Calculate the standard deviation (σ) for the replicate measurements of E_c as follows:

$$\sigma = \left[\frac{(E_1^2 + E_2^2 + E_3^2) - \frac{(E_1 + E_2 + E_3)^2}{3}}{2} \right]^{1/2}$$

If σ exceeds 0.10, repeat the replicated runs.

5.2.5.4 Measure the overall efficiency of the cyclone and nozzle, E_o, at the particle sizes and nominal gas velocities in Table 2 of this method using the following procedure.

5.2.5.5 Set the air velocity and particle size from one of the conditions in Table 2 of this method. Establish isokinetic sampling conditions and the correct flow rate in the cyclone (obtained by procedures in this section) such that the D_{50} is 10 µm. Sample long enough to obtain ±5 percent precision on total collected mass as determined by the precision and the sensitivity of measuring technique. Determine separately the nozzle catch (m_n), cyclone catch (m_c), cyclone exit tube (M_t), and collection filter catch (m_f) for each particle size and nominal gas velocity in Table 2 of this method. Calculate overall efficiency (E_o) as follows:

$$E_o = \frac{(m_n + m_c)}{(m_n + m_c + m_t + m_f)} \times 100$$

5.2.5.6 Do three replicates for each combination of gas velocity and particle size in Table 2 of this method. Use the equation below to calculate the average overall efficiency ($E_{o(avg)}$) for each combination following the procedures described in this section for determining efficiency.

$$E_{o(avg)} = (E_1 + E_2 + E_3)/3$$

Where E_1, E_2, and E_3 are replicate measurements of E_o.

5.2.5.7 Use the formula in Section 5.2.5.3 to calculate σ for the replicate measurements. If σ exceeds 0.10 or if the particle sizes and nominal gas velocities are not within the limits specified in Table 2 of this method, repeat the replicate runs.

5.2.6 Criteria for Acceptance. For each of the three gas stream velocities, plot the $E_{o(avg)}$ as a function of particle size on Figure 6 of this method. Draw smooth curves through all particle sizes. $E_{o(avg)}$ shall be within the banded region for all sizes, and the $E_{c(avg)}$ shall be 50±0.5 percent at 10 µm.

5.3 Cyclone Calibration Procedure. The purpose of this procedure is to develop the relationship between flow rate, gas viscosity, gas density, and D_{50}.

5.3.1 Calculate Cyclone Flow Rate. Determine flow rates and D_{50}'s for three different particle sizes between 5 µm and 15 µm, one of which shall be 10 µm. All sizes must be determined within 0.5 µm. For each size, use a different temperature within 60 °C (108 °F) of the temperature at which the cyclone is to be used and conduct triplicate runs. A suggested procedure is to keep the particle size constant and vary the flow rate.

5.3.1.1. On log-log graph paper, plot the Reynolds number (Re) on the abscissa, and the square root of the Stokes 50 number [$(Stk_{50})^{1/2}$] on the ordinate for each temperature. Use the following equations to compute both values:

$$Re = \frac{4 \rho Q_{cyc}}{d_{cyc} \pi \mu_{cyc}}$$

$$(Stk_{50})^{1/2} = \left[\frac{4 Q_{cyc} (D_{50})^2}{9 \pi \mu_{cyc} d_{cyc}^3} \right]^{1/2}$$

where:

Q_{cyc} = Cyclone flow rate, cm³/sec.

ρ = Gas density, g/cm³.

d_{cyc} = Diameter of cyclone inlet, cm.

μ_{cyc} = Viscosity of gas through the cyclone, micropoise.

D_{50} = Aerodynamic diameter of a particle having a 50 percent probability of penetration, cm.

5.3.1.2. Use a linear regression analysis to determine the slope (m) and the Y-intercept (b). Use the following formula to determine Q, the cyclone flow rate required for a cut size of 10 µm.

$$Q_s = \frac{\pi \mu_{cyc}}{4} \left[(3000)(K_1) - b \right]^{-1/(0.5-m)} \left[\frac{T_s}{M_s P_s} \right]^{m/(m-0.5)} d^{(m-1.5)/(m-0.5)}$$

where:

m = Slope of the calibration line.

b = y-intercept of the calibration line.

Q_s = Cyclone flow rate for a cut size of 10 µm, cm³/sec.

d = Diameter of nozzle, cm.

T_s = Stack gas temperature, R.

P_s = Absolute stack pressure, in. Hg.

M_s = Molecular weight of the stack gas, lb/lb-mole.

$K_1 = 4.077 \times 10^{-3}$.

5.3.1.3 Refer to the Method 201A operators manual, entitled *Application Guide for Source PM₁₀ Measurement with Constant*

Sampling Rate, for directions in the use of this equation for Q in the setup calculations.

5.4 Cascade Impactor. The purpose of calibrating a cascade impactor is to determine the empirical constant (STK_{50}), which is specific to the impactor and which permits the accurate determination of the cut size of the impactor stages at field conditions. It is not necessary to calibrate each individual impactor. Once an impactor has been calibrated, the calibration data can be applied to other impactors of identical design.

5.4.1 Wind Tunnel. Same as in Section 5.2.1 of this method.

5.4.2 Particle Generation System. Same as in Section 5.2.2 of this method.

5.4.3 Hardware Configuration for Calibrations. An impaction stage constrains an aerosol to form circular or rectangular jets, which are directed toward a suitable substrate where the larger aerosol particles are collected. For calibration purposes, three stages of the cascade impactor shall be discussed and designated calibration stages 1, 2, and 3. The first calibration stage consists of the collection substrate of an impaction stage and all upstream surfaces up to and including the nozzle. This may include other preceding impactor stages. The second and third calibration stages consist of each respective collection substrate and all upstream surfaces up to but excluding the collection substrate of the preceding calibration stage. This may include intervening impactor stages which are not designated as calibration stages. The cut size, or D_{50}, of the adjacent calibration stages shall differ by a factor of not less than 1.5 and not more than 2.0. For example, if the first calibration stage has a D_{50} of 12 μm, then the D_{50} of the downstream stage shall be between 6 and 8 μm.

5.4.3.1 It is expected, but not necessary, that the complete hardware assembly will be used in each of the sampling runs of the calibration and performance determinations. Only the first calibration stage must be tested under isokinetic sampling conditions. The second and third calibration stages must be calibrated with the collection substrate of the preceding calibration stage in place, so that gas flow patterns existing in field operation will be simulated.

5.4.3.2 Each of the PM_{10} stages should be calibrated with the type of collection substrate, viscid material (such as grease) or glass fiber, used in PM_{10} measurements. Note that most materials used as substrates at elevated temperatures are not viscid at normal laboratory conditions. The substrate material used for calibrations should minimize particle bounce, yet be viscous enough to withstand erosion or deformation by the impactor jets and not interfere with the procedure for measuring the collected PM.

5.4.4 Calibration Procedure. Establish test particle generator operation and verify particle size microscopically. If monodispersity is to be verified by measurements at the beginning and the end of the run rather than by an integrated sample, these measurements shall be made at this time. Measure in triplicate the PM collected by the calibration stage (m) and the PM on all surfaces downstream of the respective calibration stage (m) for all of the flow rates and particle size combinations shown in Table 2 of this method. Techniques of mass measurement may include the use of a dye and spectrophotometer. Particles on the upstream side of a jet plate shall be included with the substrate downstream, except agglomerates of particles, which shall be included with the preceding or upstream substrate. Use the following formula to calculate the collection efficiency (E) for each stage.

5.4.4.1 Use the formula in Section 5.2.5.3 of this method to calculate the standard deviation (σ) for the replicate measurements. If σ exceeds 0.10, repeat the replicate runs.

5.4.4.2 Use the following formula to calculate the average collection efficiency (E_{avg}) for each set of replicate measurements.

$$E_{avg}=(E_1+E_2+E_3)/3$$

where E_1, E_2, and E_3 are replicate measurements of E.

5.4.4.3 Use the following formula to calculate Stk for each E_{avg}.

$$Stk=\frac{D^2\,Q}{9\,\mu\,A\,d_j}$$

where:

D = Aerodynamic diameter of the test particle, cm (g/cm³)½.

Q = Gas flow rate through the calibration stage at inlet conditions, cm³/sec.

μ = Gas viscosity, micropoise.

A = Total cross-sectional area of the jets of the calibration stage, cm².

d_j = Diameter of one jet of the calibration stage, cm.

5.4.4.4 Determine Stk_{50} for each calibration stage by plotting E_{avg} versus Stk on log-log paper. Stk_{50} is the Stk number at 50 percent efficiency. Note that particle bounce can cause efficiency to decrease at high values of Stk. Thus, 50 percent efficiency can occur at multiple values of Stk. The calibration data should clearly indicate the value of Stk_{50} for minimum particle bounce. Impactor efficiency versus Stk with minimal particle bounce is characterized by a monotonically increasing function with constant or increasing slope with increasing Stk.

5.4.4.5 The Stk_{50} of the first calibration stage can potentially decrease with decreasing nozzle size. Therefore, calibrations should be performed with enough nozzle sizes to provide a measured value within 25 percent of any nozzle size used in PM_{10} measurements.

5.4.5 Criteria For Acceptance. Plot E_{avg} for the first calibration stage versus the square root of the ratio of Stk to Stk_{50} on Figure 9 of this method. Draw a smooth curve through all of the points. The curve shall be within the banded region.

6. Calculations

6.1 Nomenclature.

B_{ws} = Moisture fraction of stack, by volume, dimensionless.

C_1 = Viscosity constant, 51.12 micropoise for °K (51.05 micropoise for °R).

C_2 = Viscosity constant, 0.372 micropoise/°K (0.207 micropoise/°R).

C_3 = Viscosity constant, 1.05×10^{-4} micropoise/°K² (3.24×10^{-5} micropoise/°R²).

C_4 = Viscosity constant, 53.147 micropoise/fraction O_2.

C_5 = Viscosity constant, 74.143 micropoise/fraction H_2O.

D_{50} = Diameter of particles having a 50 percent probability of penetration, μm.

f_{O_2} = Stack gas fraction O_2, by volume, dry basis.

K_1 = 0.3858 °K/mm Hg (17.64 °R/in. Hg).

M_w = Wet molecular weight of mixed gas through the PM_{10} cyclone, g/g-mole (lb/lb-mole).

M_d = Dry molecular weight of stack gas, g/g-mole (lb/lb-mole).

P_{bar} = Barometric pressure at sampling site, mm Hg (in. Hg).

P_s = Absolute stack pressure, mm Hg (in. Hg).

Q_s = Total cyclone flow rate at wet cyclone conditions, m³/min (ft³/min).

$Q_{s(std)}$ = Total cyclone flow rate at standard conditions, dscm/min (dscf/min).

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

T_s = Average absolute stack gas temperature, °K (°R).

$V_{w(std)}$ = Volume of water vapor in gas sample (standard conditions), scm (scf).

θ = Total sampling time, min.

μ_{cyc} = Viscosity of mixed cyclone gas, micropoise.

μ_{std} = Viscosity of standard air, 180.1 micropoise.

6.2 Analysis of Cascade Impactor Data. Use the manufacturer's recommended procedures to analyze data from cascade impactors.

6.3 Analysis of Cyclone Data. Use the following procedures to analyze data from a single stage cyclone.

6.3.1 PM_{10} Weight. Determine the PM catch in the PM_{10} range from the sum of the weights obtained from Container Numbers 1 and 3 less the acetone blank.

6.3.2 Total PM Weight (optional). Determine the PM catch for greater than PM_{10} from the weight obtained from Container Number 2 less the acetone blank, and add it to the PM_{10} weight.

6.3.3 PM_{10} Fraction. Determine the PM_{10} fraction of the total particulate weight by dividing the PM_{10} particulate weight by the total particulate weight.

6.3.4 Aerodynamic Cut Size. Calculate the stack gas viscosity as follows:

$$\mu_{cyc}=C_1+C_2T_s+C_3T_s^2+C_4f_{O_2}-C_5B_{ws}$$

6.3.4.1 The PM_{10} flow rate, at actual cyclone conditions, is calculated as follows:

$$Q_s=\frac{T_s}{K_1\,P_s}\left[Q_{s(std)}+\frac{V_{w(std)}}{\theta}\right]$$

6.3.4.2 Calculate the molecular weight on a wet basis of the stack gas as follows:

$$M_w=M_d(1-B_{ws})+18.0(B_{ws})$$

6.3.4.3 Calculate the actual D_{50} of the cyclone for the given conditions as follows:

$$D_{50} = \beta_1 \left[\frac{T_s}{M_s P_s} \right]^{0.2091} \left[\frac{\mu_{s}}{Q_s} \right]^{0.7091}$$

where β_1 = 0.027754 for metric units (0.15825 for English units).

6.3.5 Acceptable Results. The results are acceptable if two conditions are met. The first is that 9.0 µm < D_{50} < 11.0 µm. The second is that no sampling points are outside Δp_{min} and Δp_{max}, or that 80 percent < I < 120 percent and no more than one sampling point is outside Δp_{min} and Δp_{max}. If D_{50} is less than 9.0 µm, reject the results and repeat the test.

Bibliography

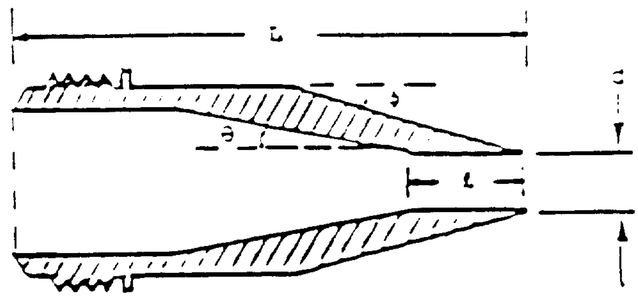
1. Same as Bibliography in Method 5.

2. McCain, J.D., J.W. Ragland, and A.D. Williamson. Recommended Methodology for the Determination of Particle Size Distributions in Ducted Sources. Final Report. Prepared for the California Air Resources Board by Southern Research Institute. May 1986.

3. Farthing, W.E., S.S. Dawes, A.D. Williamson, J.D. McCain, R.S. Martin, and J.W. Ragland. Development of Sampling Methods for Source PM_{10} Emissions. Southern Research Institute for the Environmental Protection Agency. April 1989. NTIS PB 89 190375. EPA/600/3-88-056.

4. *Application Guide for Source PM_{10} Measurement with Constant Sampling Rate.* EPA/600/3-88-057.

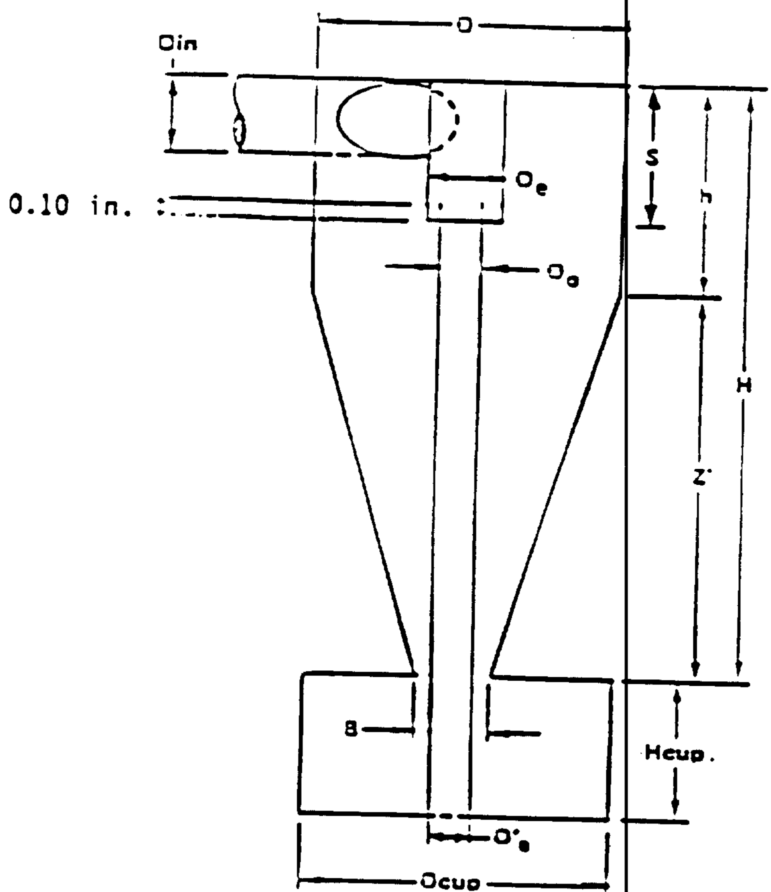
BILLING CODE 6560-50-M



Nozzle Diameter (inches)	Cone Angle, θ (degrees)	Outside taper, δ (degrees)	Straight inlet length, ℓ (inches)	Total Length L (inches)
0.136	4	15	<0.05	2.653±0.05
0.150	4	15	<0.05	2.553±0.05
0.164	5	15	<0.05	1.970±0.05
0.180	6	15	<0.05	1.572±0.05
0.197	6	15	<0.05	1.491±0.05
0.215	6	15	<0.05	1.45 ±0.05
0.233	6	15	<0.05	1.45 ±0.05
0.264	5	15	<0.05	1.45 ±0.05
0.300	4	15	<0.05	1.48 ±0.05
0.342	4	15	<0.05	1.45 ±0.05
0.390	3	15	<0.05	1.45 ±0.05

Figure 2. Nozzle design specifications.

Cyclone Interior Dimensions



	Dimensions (±0.02 cm, ±0.01 in.)											
	Din	D	De	B	H	h	Z	S	Hcup	Dcup	D'e	Do
cm	1.27	4.47	1.50	1.88	6.95	2.24	4.71	1.57	2.25	4.45	1.02	1.24
inches	0.50	1.76	0.59	0.74	2.74	0.88	1.85	0.62	0.89	1.75	0.40	0.49

Figure 3. Cyclone design specifications.

Barometric pressure.

P_{bar}, in. Hg = ________

Stack static pressure.

P_g, in. H_2O = ________

Average stack temperature.

t_s, °F = ________

Meter temperature, t_m, °F = ________

Orifice $\Delta H_@$, in. H_2O = ________

Gas analysis:

$\%CO_2$ = ________

$\%O_2$ = ________

$\%N_2 + \%CO$ = ________

Fraction moisture content.

B_{ws} = ________

Molecular weight of stack gas, dry basis:

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$ = ________ lb/lb mole

Molecular weight of stack gas, wet basis:

$M_w = M_d\ (1-B_{ws}) + 18\ (B_{ws})$ = ________ lb/lb mole

Absolute stack pressure:

$$P_s = P_{bar} + \frac{P_g}{13.6} = \_\_\_\_\_\_\_\_ \text{ in. Hg}$$

Viscosity of stack gas:

$\mu_s = 152.418 + 0.2552\ t_s + 3.2355 \times 10^{-5}\ t_s^2 + 0.53147\ (\%O_2) - 74.143\ B_{ws}$ = ________ micropoise

Cyclone flow rate:

$$Q_s = 0.002837\ \mu_s \left\{ \frac{(t_s + 460)}{M_w P_s} \right\}^{0.2949} = \_\_\_\_\_\_\_\_ \text{ ft}^3\text{/min}$$

Figure 4. Example worksheet 1, cyclone flow rate and ΔH.

Orifice pressure head (ΔH) needed for cyclone flow rate:

$$\Delta H = \left[\frac{Q_s\ (1-B_{ws})\ P_s}{t_s + 460} \right]^2 \frac{t_m\ M_d\ 1.083\ \Delta H_@}{P_{bar}} = \_\_\_\_\_\_\_\_ \text{ in. } H_2O$$

Calculate ΔH for three temperatures:

t_m °F			
ΔH, in. H_2O			

Stack viscosity, μ_s, micropoise = ________

Absolute stack pressure.

P_s, in. Hg = ________

Average stack temperature.

t_s, °F = ________

Meter temperature, t_m, °F = ________

Method 201A pitot coefficient.

C_p = ________

Cyclone flow rate, ft³/min.

Q_s = ________

Method 2 pitot coefficient.

C_p' = ________

Molecular weight of stack gas, wet basis.

M_w = ________

Nozzle diameter, D_n, in. = ________

Nozzle velocity:

$$v_n = \frac{3.056\ Q_s}{D_n^2} = \_\_\_\_\_\_\_\_ \text{ ft/sec}$$

Maximum and minimum velocities:

$$v_{min} = v_n \left[0.2457 + \left(0.3072 - \frac{0.2803\ Q_s^{1/2}\ \mu_s}{v_n^{1.5}} \right)^{1/2} \right] = \_\_\_\_\_\_\_\_ \text{ ft/sec}$$

$$v_{max} = v_n \left[0.4457 + \left(0.5090 - \frac{0.2803\ Q_s^{1/2}\ \mu_s}{v_n^{1.5}} \right)^{1/2} \right] = \_\_\_\_\_\_\_\_ \text{ ft/sec}$$

Figure 5. Example worksheet 2, nozzle selection.

Maximum and minimum velocity head values:

$$\Delta p_{min} = 1.3086 \times 10^{-4}\ \frac{P_s\ M_w\ (v_{min})^2}{(t_s + 460)\ C_p^2} = \_\_\_\_\_\_\_\_ \text{ in. } H_2O$$

$$\Delta p_{min} = 1.3686 \times 10^{-4} \left[\frac{P_s M_w (v_{min})^2}{(t_s + 460) C_p^2}\right] = \underline{\qquad} \text{ in. } H_2O$$

Nozzle No		
D_n, in.		
v_n, ft/sec		
v_{max}, ft/sec		
v_{min}, ft/sec		
Δp_{max}, in. H_2O		
Δp_{min}, in. H_2O		

Velocity traverse data:

$$\Delta p(\text{Method 201A}) = \Delta p(\text{Method 2}) \left[\frac{C_p}{C_p'}\right]^2$$

Total run time, minutes = ________

Number of traverse points = ________

$$t_1 = \left[\frac{\Delta p'_1}{\Delta p'_{avg}}\right]^{1/2} \frac{\text{(Total run time)}}{\text{(Number of points)}}$$

where:

t_1 = dwell time at first traverse point, minutes.

$\Delta p'_1$ = the velocity head at the first traverse point (from a previous traverse), in. H_2O.

$\Delta p'_{avg}$ = the square of the average square root of the Δp's (from a previous velocity traverse), in. H_2O.

At subsequent traverse points, measure the velocity Δp and calculate the dwell time by using the following equation:

$$t_n = \frac{t_1}{(\Delta p_n)^{1/2}} (\Delta p_1)^{1/2}, \quad n = 2, 3, \ldots \text{ total number of sampling points}$$

where:

t_n = dwell time at traverse point n, minutes.

Δp_n = measured velocity head at point n, in. H_2O.

Δp_1 = dwell time at first traverse point, minutes.

Figure 6. Example worksheet 3, dwell time.

Point No	Port							
	Δp	t	Δp	t	Δp	t	Δp	t
1								
2								
3								
4								
5								
6								

Plant ________

Date ________

Run no. ________

Filter no. ________

Amount of liquid lost during transport ________

Acetone blank volume, ml ________

Acetone wash volume, ml (4) ________ (5) ________

Acetone blank conc., mg/mg (Equation 5–4, Method 5) ________

Acetone wash blank, mg (Equation 5–5, Method 5) ________

Container No.	Weight of PM_{10} (mg)		
	Final weight	Tare weight	Weight gain
1			
3			
Total			
Less acetone blank			
Weight of PM_{10}			

Figure 7. Method 201A analysis sheet.

TABLE 1.—PERFORMANCE SPECIFICATIONS FOR SOURCE PM_{10} CYCLONES AND NOZZLE COMBINATIONS

Parameter	Units	Specifications
1. Collection efficiency.	Percent	Such that collection efficiency falls within envelope specified by Section 6.2.6 and Figure 8.
2. Cyclone cut size (D_{50}).	µm	10 ± 1 µm aerodynamic diameter.

TABLE 2.—PARTICLE SIZES AND NOMINAL GAS VELOCITIES FOR EFFICIENCY

Particle size (μm)[a]	Target gas velocities (m/sec)		
	7 ± 1.0	15 ± 1.5	25 ± 2.5
5 ± 0.5			
7 ± 0.5			
10 ± 0.5			
14 ± 1.0			
20 ± 1.0			

[a] Mass median aerodynamic diameter.

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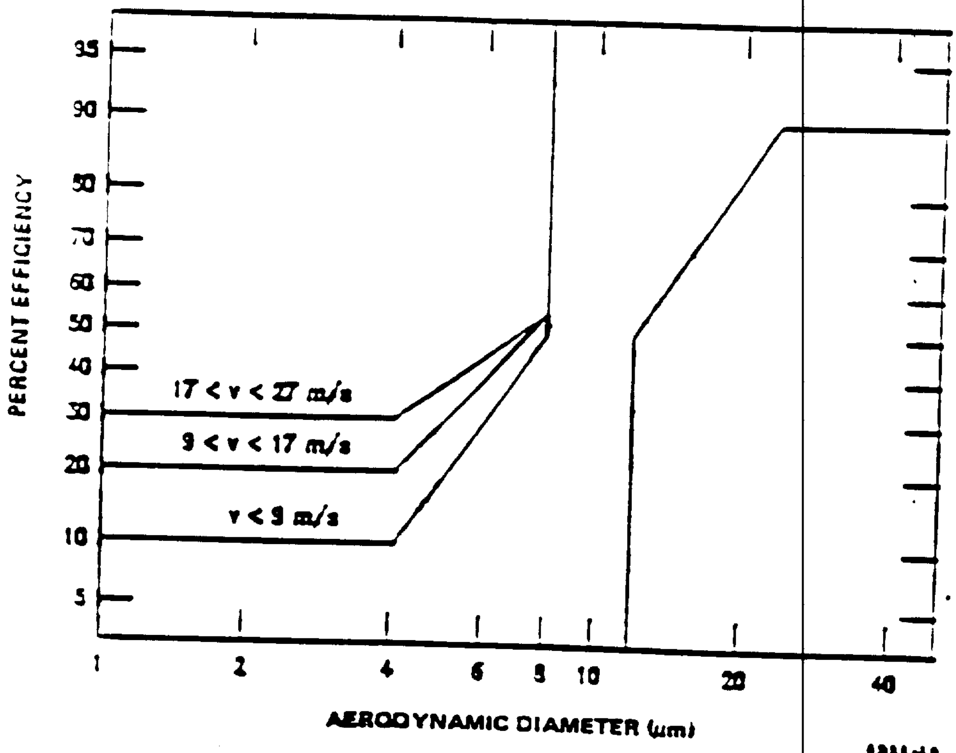


Figure 8. Efficiency envelope for the PM_{10} cyclone.

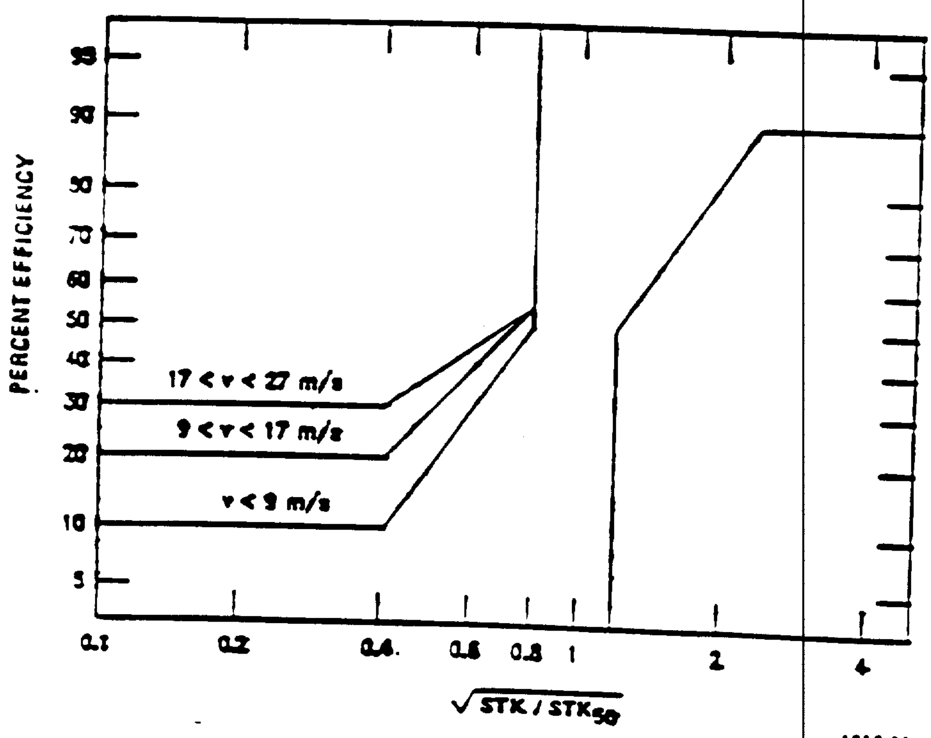


Figure 9. Efficiency envelope for first calibration stage.

[FR Doc. 90-7603 Filed 4-16-90; 8:45 am]

BILLING CODE 6560-50-M

APPENDIX I.

Additional Information

Raleigh Durham

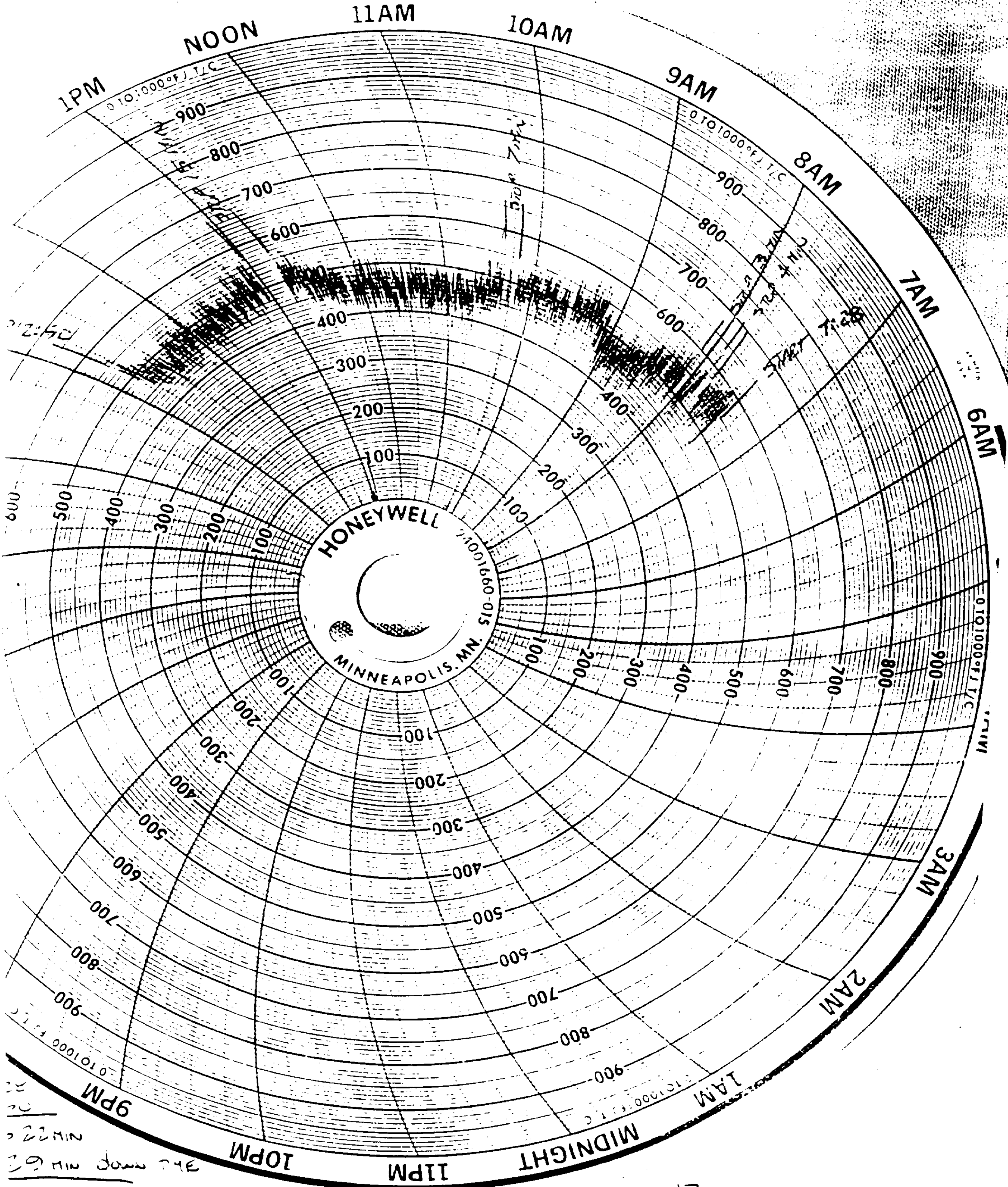
Date	(Tons) Production	(Hrs) Run Time	Tons/Hour
12-16-91	3035	6.88	441
12-17	2962	5.47	541
12-18	2755	4.92	560
12-19	2180	4.25	513
12-20	3206	5.90	543
1-2-92	3750	6.96	540
1-6-92	3756	6.38	589

CONVEYOR No 5 BELT LENGTH - 420'

SPECIFIC GRAVITY OF STONE - 2.75

BELT SCALE IS LOCATED ON CONVEYOR No 2. APPROXIMATELY 80 TONS PER HOUR IS TAKEN OUT OF THE SYSTEM AT CONVEYOR No 7 FOR ABC STOCKPILE. A RECIRCULATING LOAD OF 80 TO 100 TPH PASSES THRU THE 1560 OMNICONE CRUSHER. THIS MATERIAL PASSES BACK OVER THE TEST SCREEN.

THE TEST SCREEN RECEIVES APPROX. 60% OF THE MATERIAL FROM CONVEYOR 5 WITH 40% GOING TO THE ADJACENT SIZING SCREEN.



22 MIN

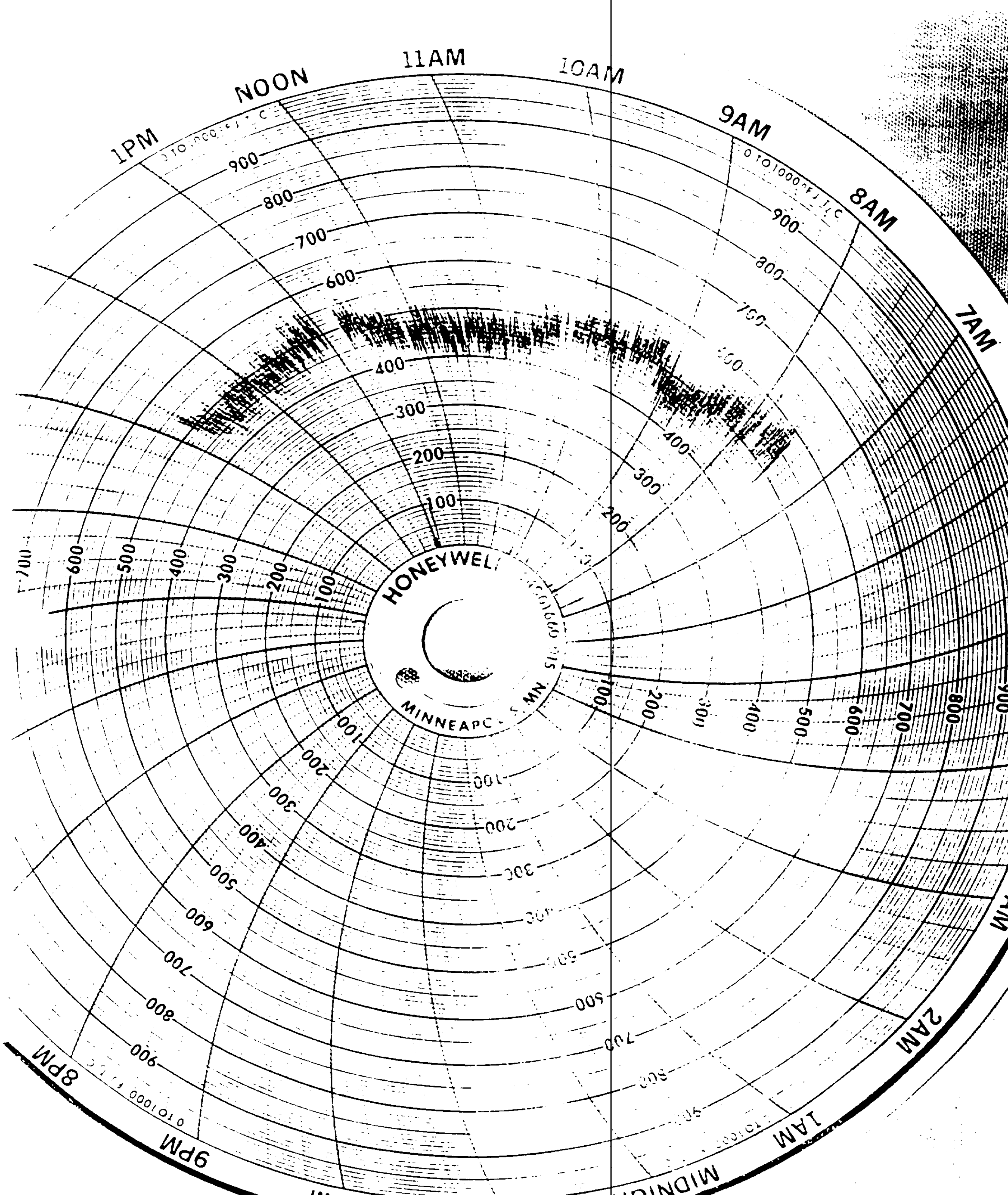
39 MIN down TIME

53 MIN = 0.88 hrs

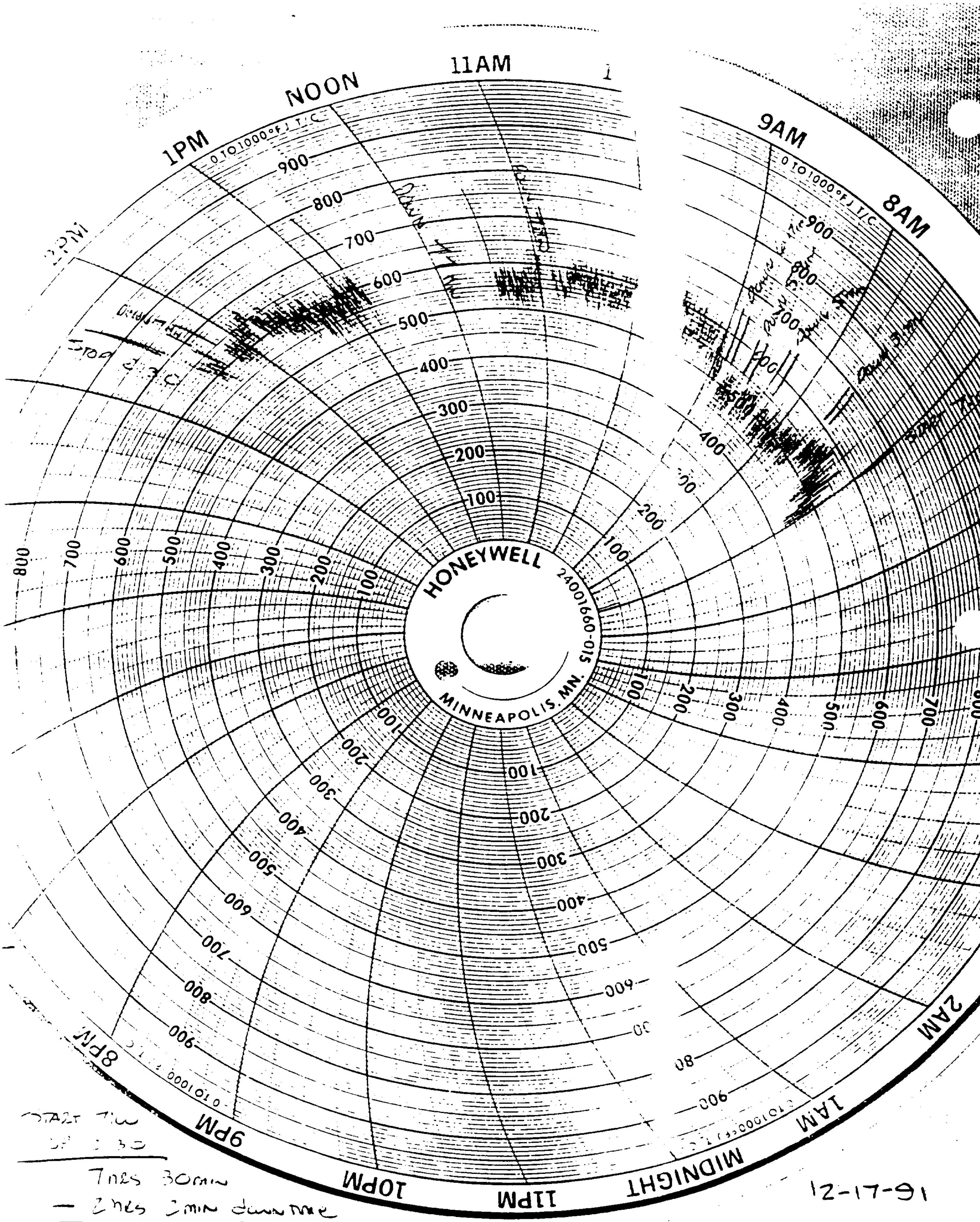
441 TPH

12-16-91

302C


11AM
10AM
NOON
9AM
1PM
8AM
7AM
2AM
1AM
MIDNIGHT
11PM
10PM
9PM
8PM
HONEYWEL
MINNEAPC
0 TO 1000 °F/ °C

12-16-91
3035



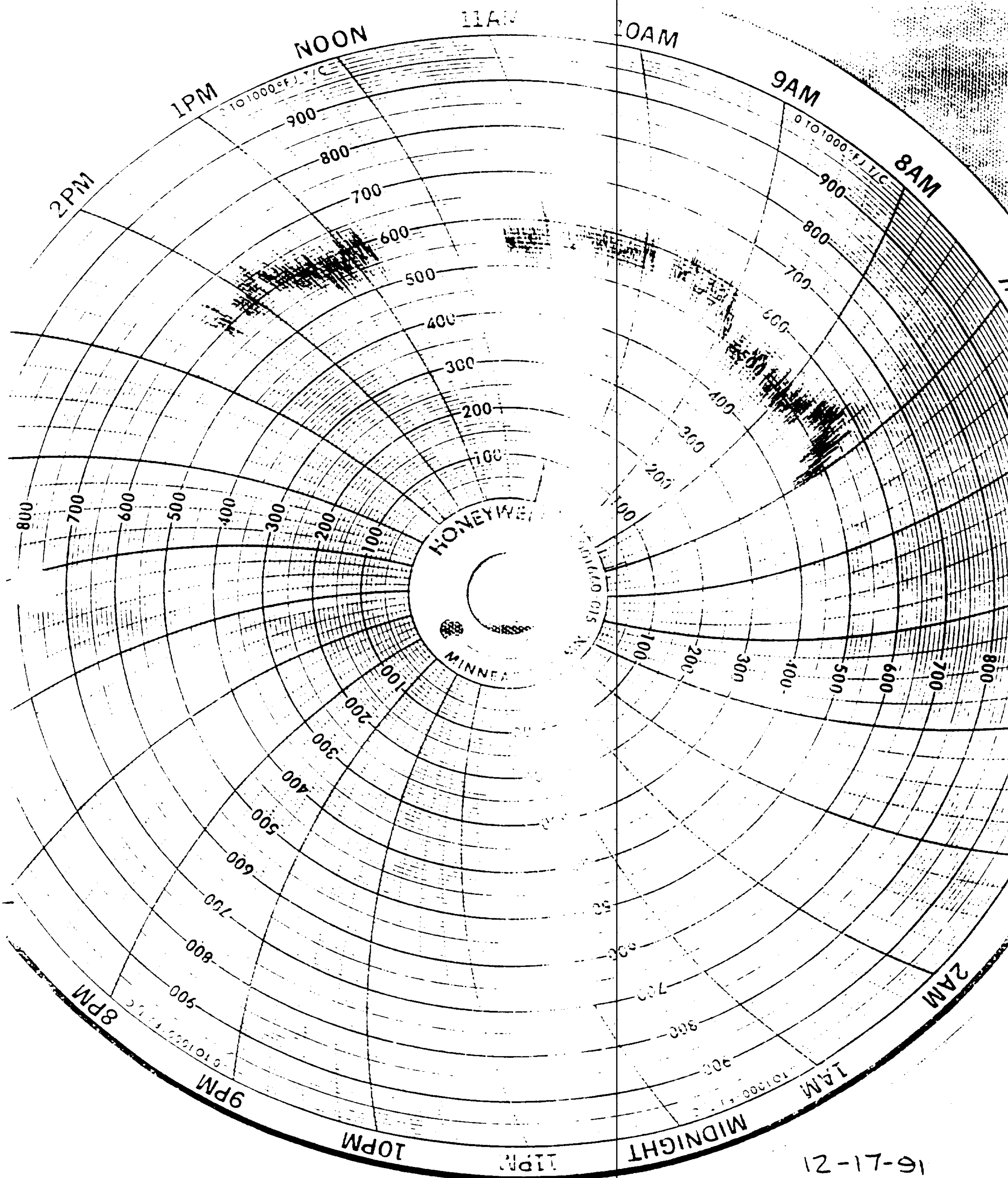
START TIME
3P 3:30

7 hrs 30 min
− 2 hrs 2 min down time

5 hrs 28 min = 5.47 hrs

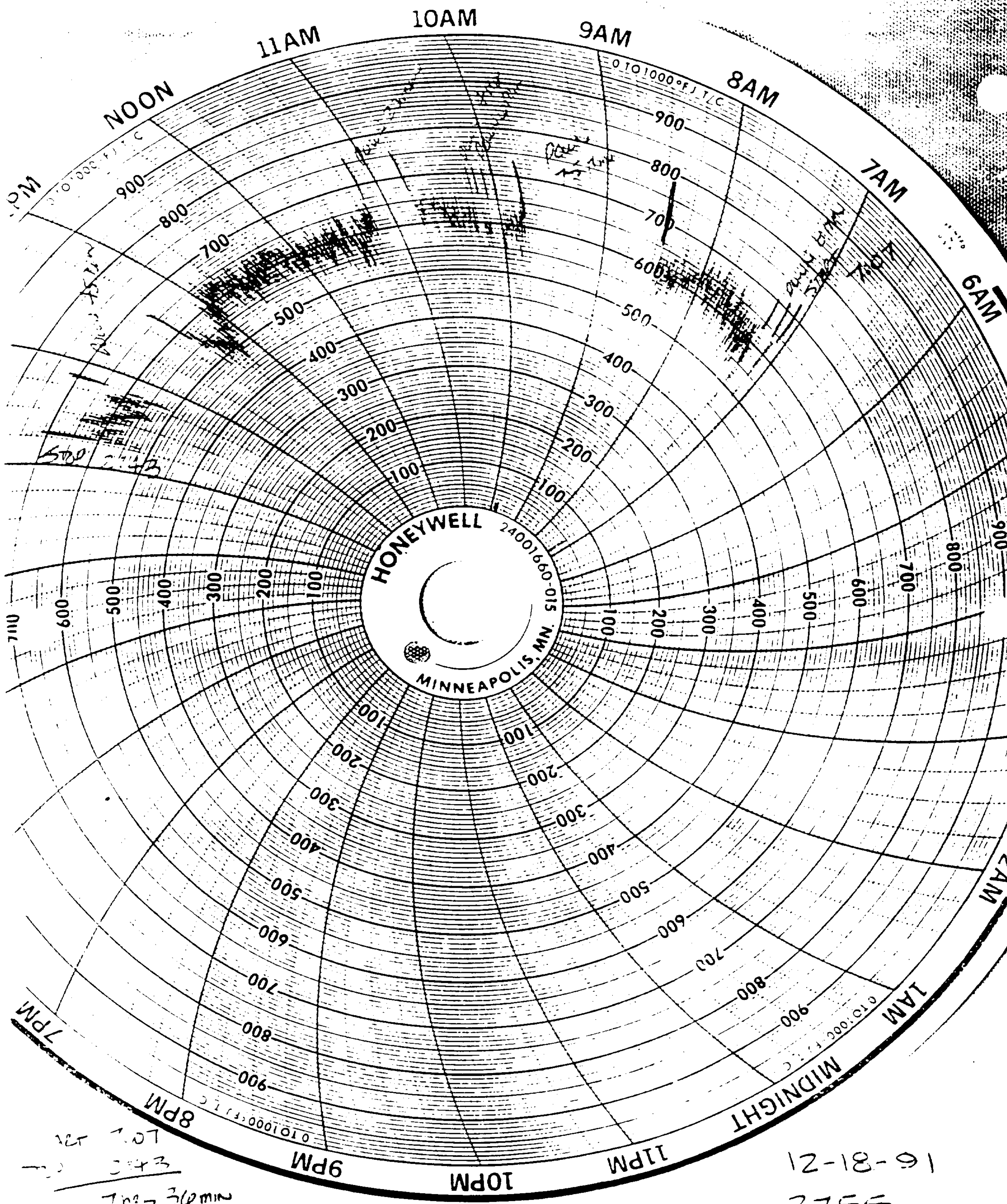
541 tph

12-17-91
2962



NOON
1PM
2PM
9AM
8AM
0 TO 1000°F J T/C
900
800
700
600
500
400
300
200
100
HONEYWE
MINNEA
2AM
1AM
MIDNIGHT
10PM
9PM
8PM

12-17-91
2962

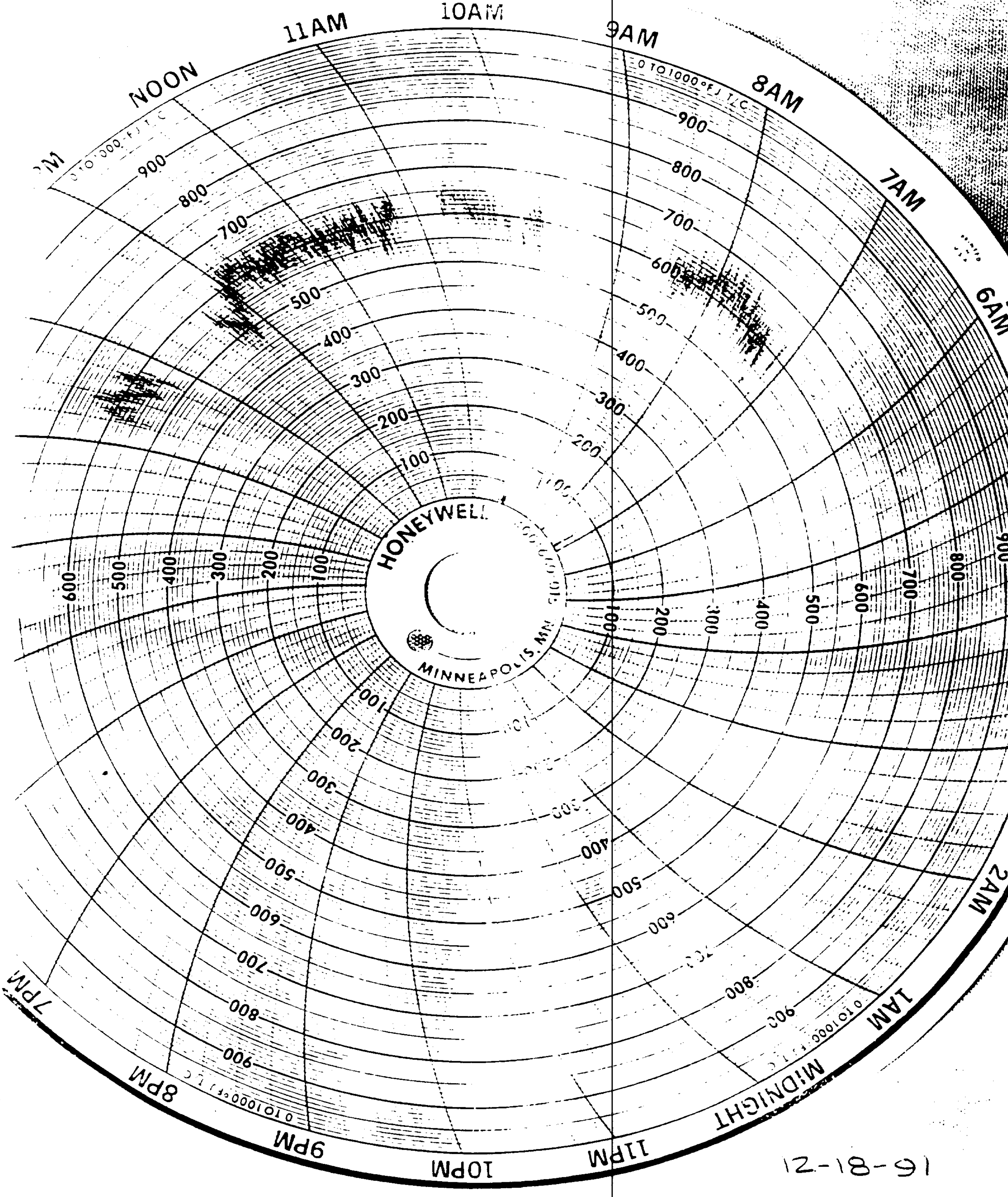


1ST 7.07
3+3

7hrs 36min
2hrs 41min down time
4.92 hrs

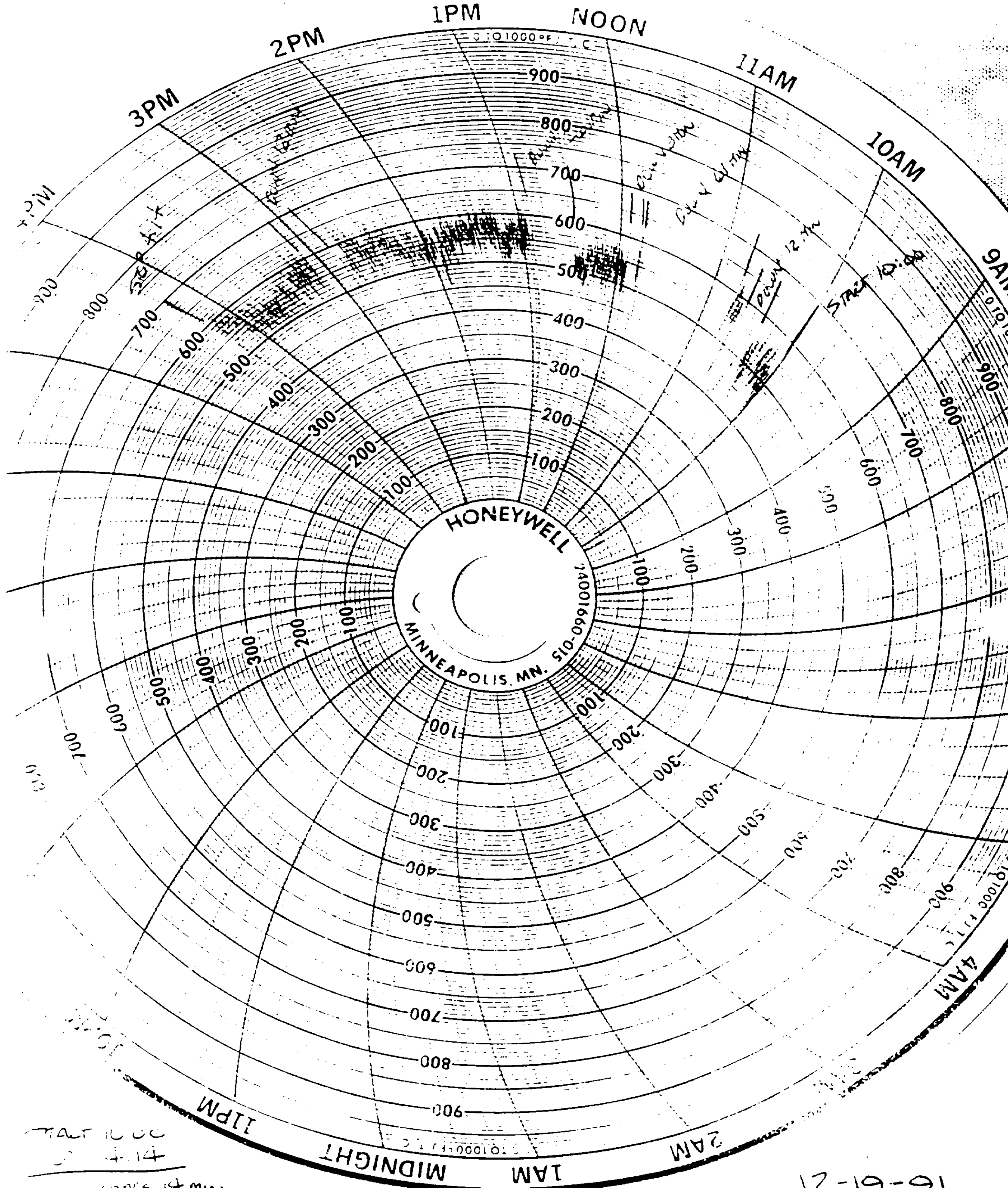
500 TPH

12-18-91
2755



HONEYWELL
MINNEAPOLIS, MN
0 TO 1000 °F J T/C
NOON
11AM
10AM
9AM
8AM
7AM
6AM
2AM
1AM
MIDNIGHT
11PM
10PM
9PM
8PM
7PM

12-18-91
2755



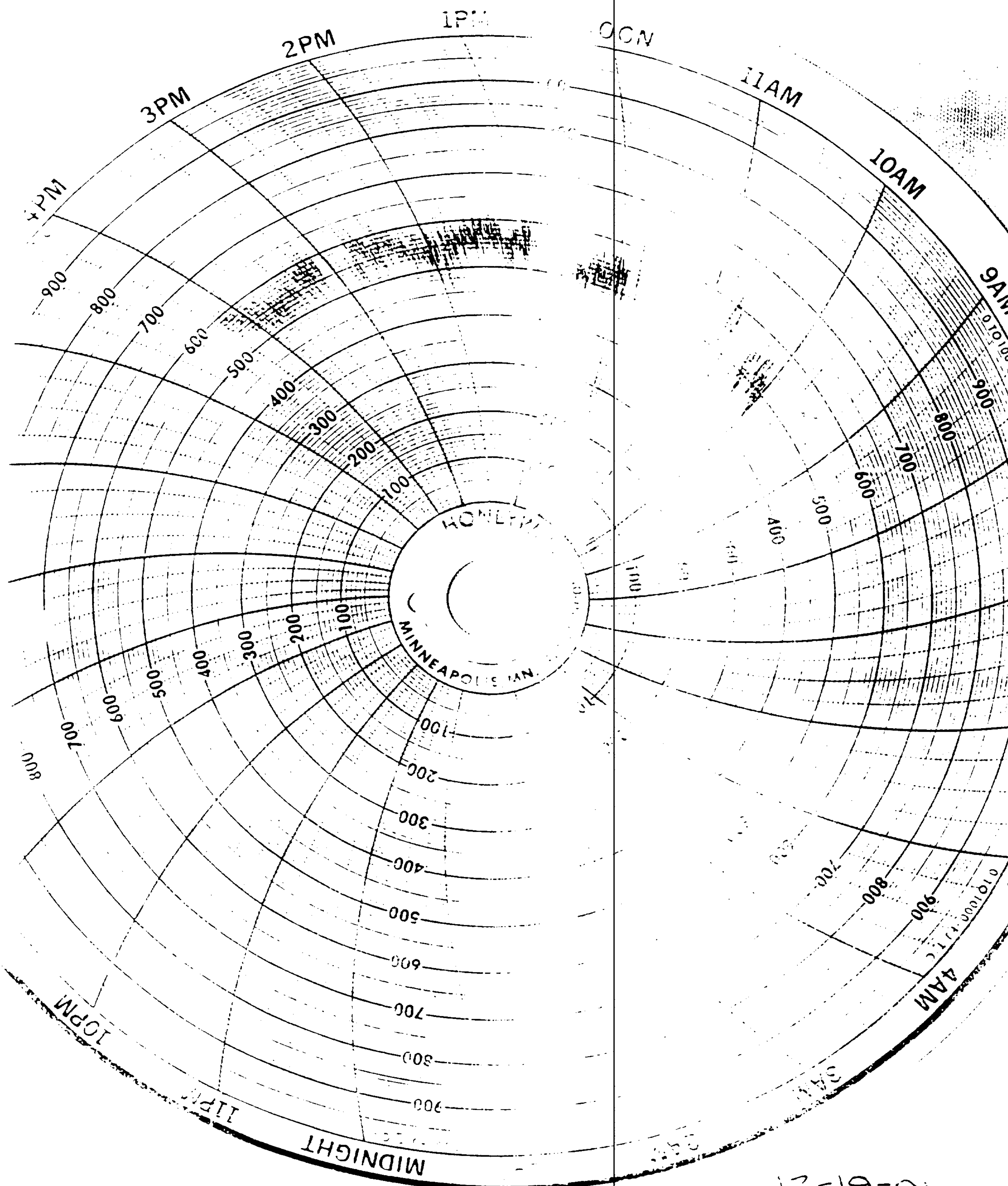
START 10:00
4:14

6 hrs 14 min
– 1 hr 59 min down time

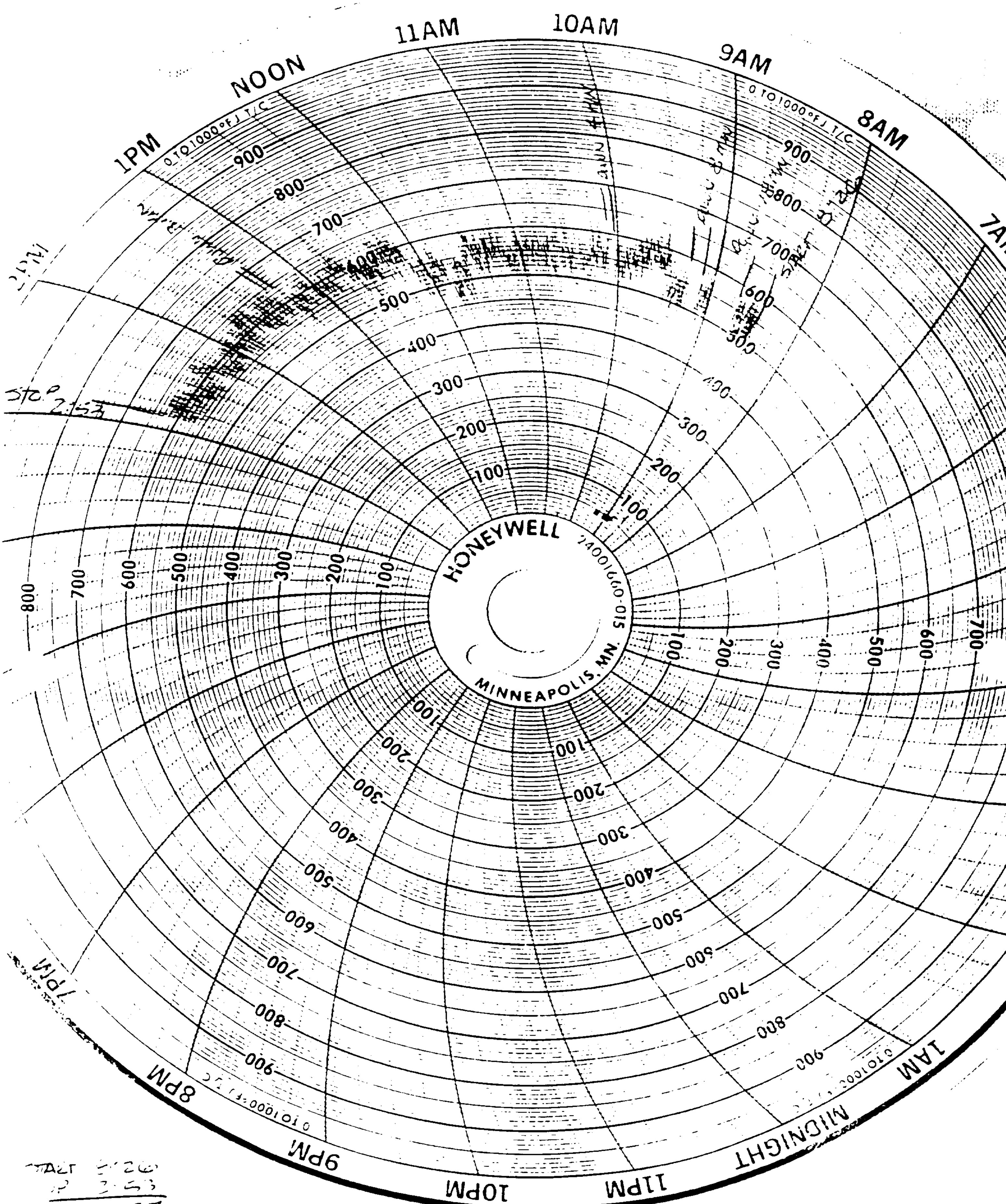
4.25 hrs

513 TPH

12-19-91
2180


2PM
3PM
11AM
10AM
4AM
10PM
MIDNIGHT
100
200
300
400
500
600
700
800
900

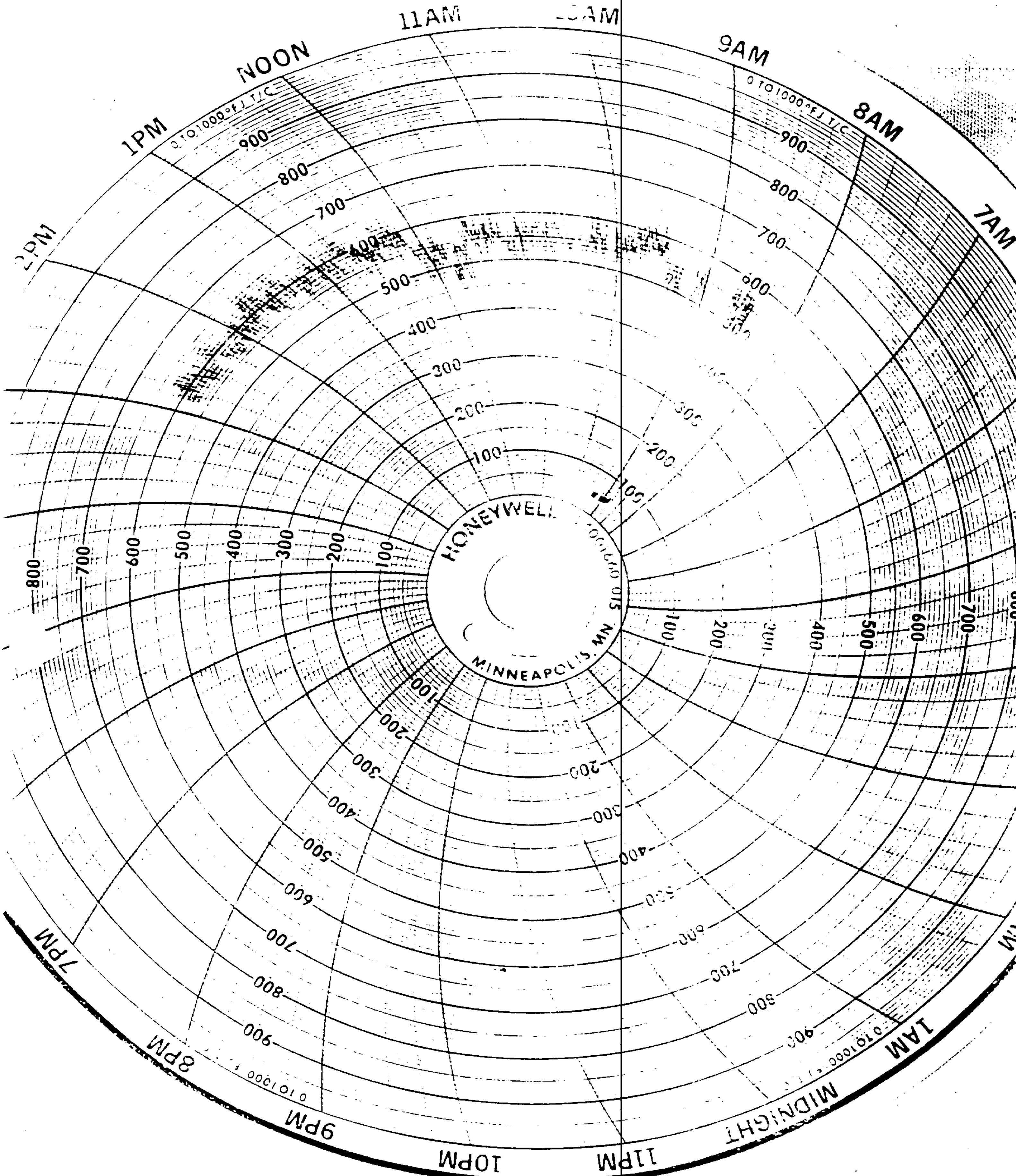
12-19-91
2180



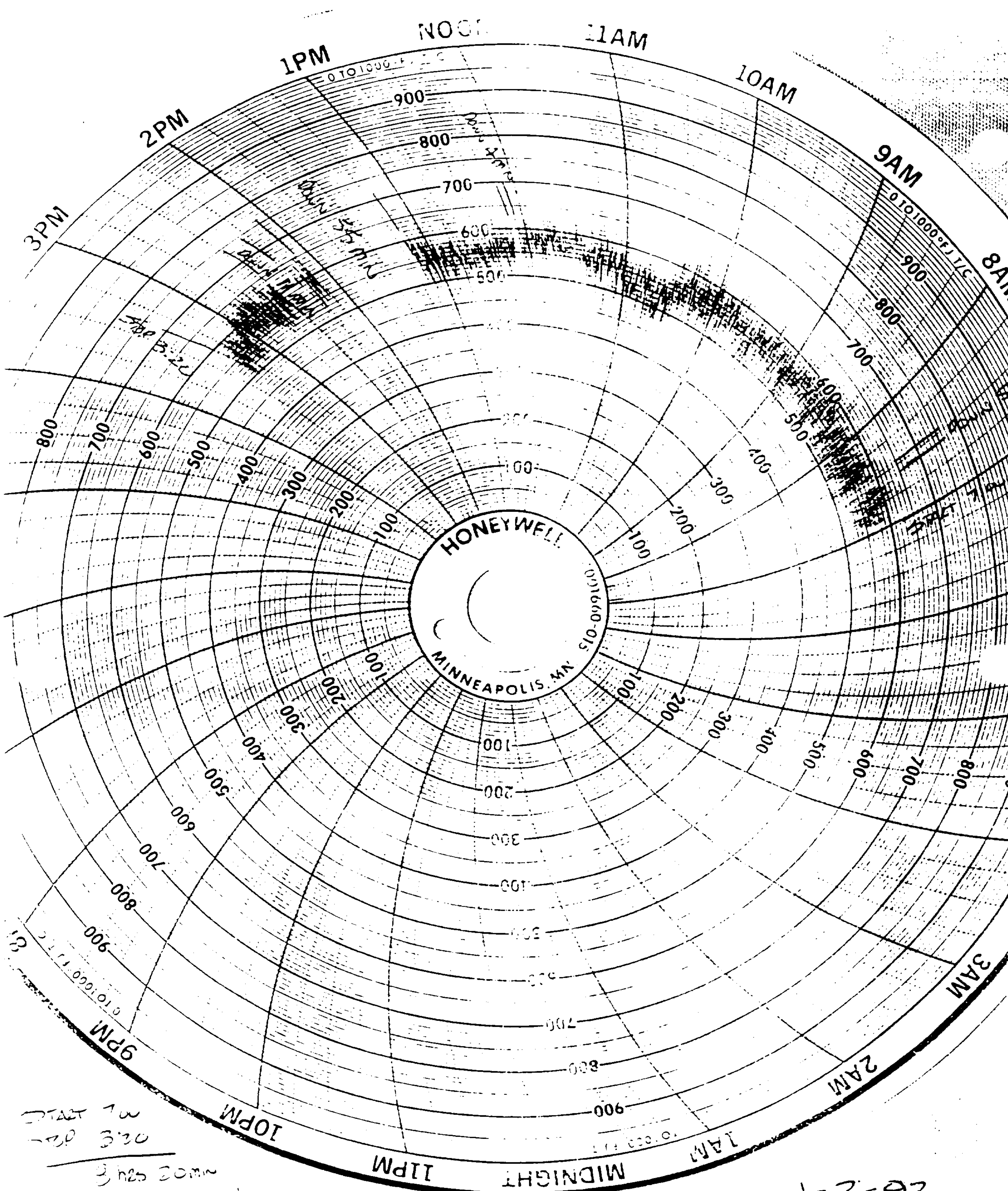
Start 8:26
Stop 2:53
6:27
− 33 min down time
5 hr 54 min = 5.9 Hrs

543 TPH

12-20-91
3206


11AM
NOON
1PM
2PM
9AM
8AM
7AM
1AM
MIDNIGHT
11PM
10PM
9PM
8PM
7PM
0 TO 1000°F J T/C
HONEYWELL
MINNEAPOLIS, MN

12-20-91
3206



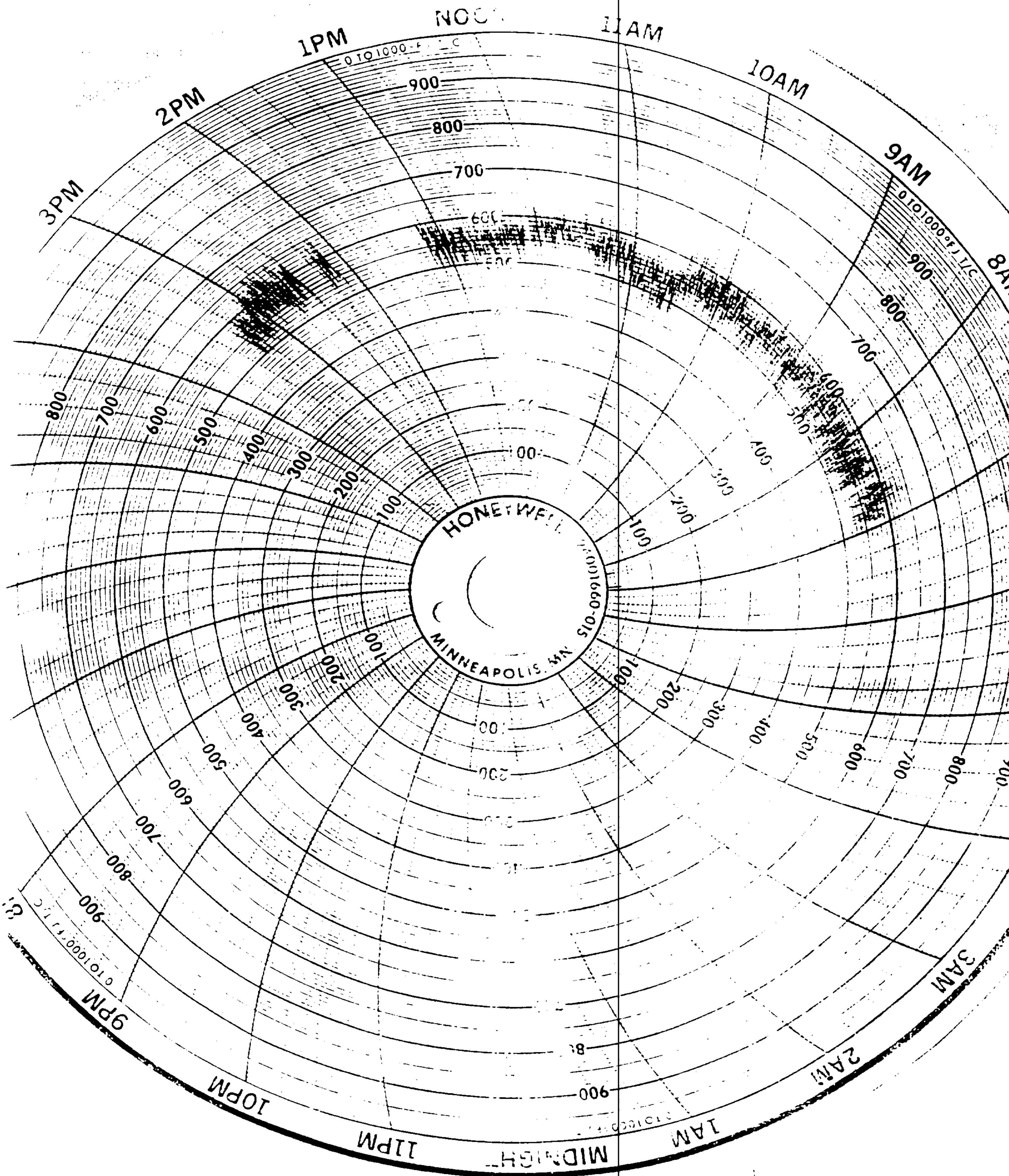
START 7 00
STOP 3:20

8 hrs 20 min
- 1 hr 22 min down time

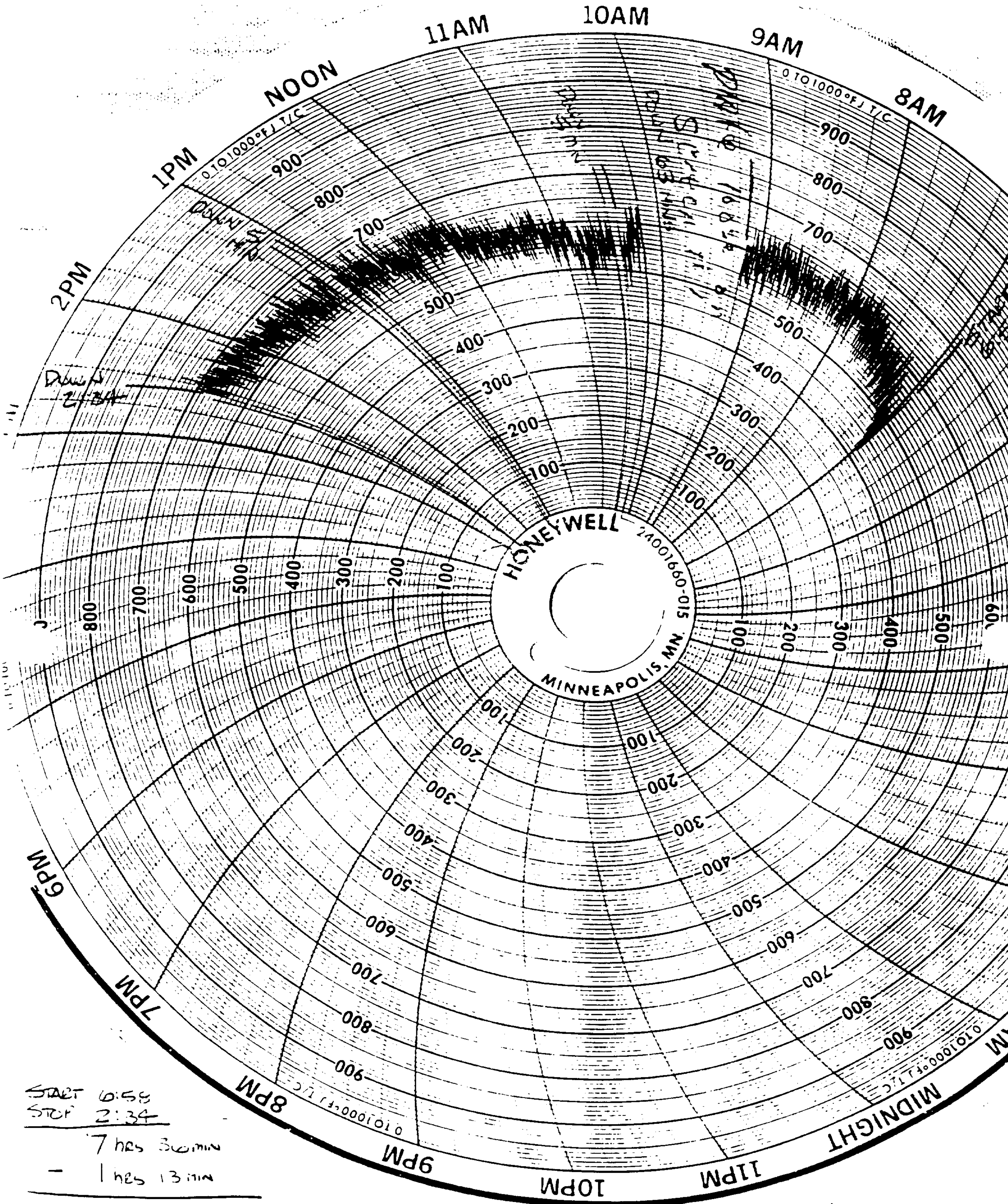
6 hrs 58 min

540 TPh

1-2-92
3750 TONS


NOON
11AM
10AM
9AM
1PM
2PM
3PM
9PM
10PM
11PM
MIDNIGHT
1AM
2AM
3AM
HONEYWELL
MINNEAPOLIS, MN
0 TO 1000°F J/C
100
200
300
400
500
600
700
800
900

1-2-92
3750



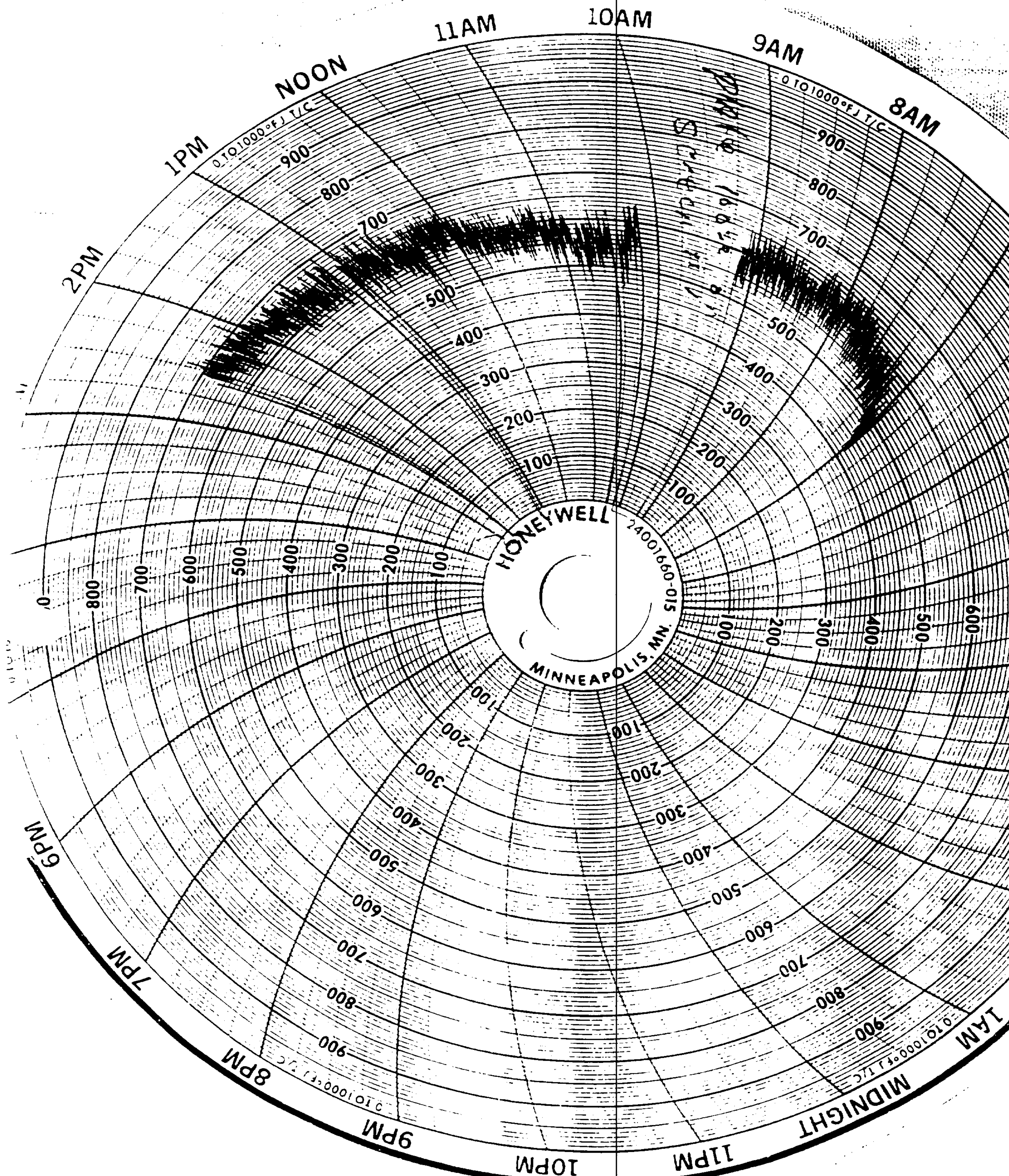
START 6:58
STOP 2:34

7 hrs 36 min
- 1 hrs 13 min

6 hrs 23 min = 6.38 hrs

589 TPH

1-6-92
3756


10AM
9AM
8AM
11AM
NOON
1PM
2PM
6PM
7PM
8PM
9PM
10PM
11PM
MIDNIGHT
1AM
0 TO 1000°F J T/C
HONEYWELL
MINNEAPOLIS, MN.
24001660-015

1-6-92
3756

KEY TO AVIATION WEATHER OBSERVA[illegible] . . . .

NOAA/PA 73029

LOCATION IDENTIFIER TYPE AND TIME OF REPORT*	SKY AND CEILING	VISIBILITY WEATHER AND OBSTRUCTION TO VISION	SEA-LEVEL PRESSURE	TEMPERATURE AND DEW POINT	WIND	ALTIMETER SETTING	REMARKS AND CODED DATA
MKC SA 0758	15 SCT M25 OVC	1R-K	132	/58/56	/1807	/993/	R04LVR20V40

SKY AND CEILING

Sky cover contractions are in ascending order. Figures preceding contractions are heights in hundreds of feet above station. Sky cover contractions are:

- CLR Clear: Less than 0.1 sky cover.
- SCT Scattered: 0.1 to 0.5 sky cover.
- BKN Broken: 0.6 to 0.9 sky cover.
- OVC Overcast: More than 0.9 sky cover
- — Thin (When prefixed to SCT, BKN, OVC)
- —X Partial obscuration: 0.9 or less of sky hidden by precipitation or obstruction to vision (bases at surface.)
- X Obscuration: 1.0 sky hidden by precipitation or obstruction to vision (bases at surface).

Letter preceding height of layer identifies ceiling layer and indicates how ceiling height was obtained. Thus:

- E Estimated height
- M Measured
- W Indefinite

V = Immediately following numerical value, indicates a variable ceiling.

VISIBILITY

Reported in statute miles and fractions. (V = Variable)

WEATHER AND OBSTRUCTION TO VISION SYMBOLS

A	Hail	IC	Ice crystals	S	Snow
BD	Blowing dust	IF	Ice fog	SG	Snow grains
BN	Blowing sand	IP	Ice pellets	SP	Snow pellets
BS	Blowing snow	IPW	Ice pellet showers	SW	Snow showers
D	Dust	K	Smoke	T	Thunderstorms
F	Fog	L	Drizzle	T+	Severe thunderstorm
GF	Ground fog	R	Rain	ZL	Freezing drizzle
H	Haze	RW	Rain showers	ZR	Freezing rain

Precipitation intensities are indicated thus: — Light; (no sign) Moderate; — Heavy

WIND

Direction in tens of degrees from true north, speed in knots. 0000 indicates calm. G indicates gusty. Peak speed of gusts follows G or Q when gusts or squall are reported. The contraction WSHFT followed by GMT time group in remarks indicates windshift and its time of occurrence. (Knots × 1.15 = statute mi/hr.)

EXAMPLES: 3627 = 360 Degrees, 27 knots; 3627G40 = 360 Degrees, 27 knots, peak speed in gusts 40 knots.

ALTIMETER SETTING

The first figure of the actual altimeter setting is always omitted from the report.

RUNWAY VISUAL RANGE (RVR)

RVR is reported from some stations. Extreme values during 10 minutes prior to observation are given in hundreds of feet. Runway identification precedes RVR report.

PILOT REPORTS (PIREPS)

When available, PIREPS, in fixed-formats are appended to weather observations. The PIREP is designated by UA

DECODED REPORT

Kansas City: Record observation taken at 0758 GMT 1500 feet scattered clouds, measured ceiling 2500 feet overcast, visibility 1 mile, light rain, smoke, sea-level pressure 1013.2 millibars, temperature 58°F, dewpoint 56°F, wind 180°, 7 knots, altimeter setting 29.93 inches. Runway 04 left, visual range 2000 feet variable to 4000 feet.

***TYPE OF REPORT**

SA—a scheduled record observation

SP—an unscheduled special observation indicating a significant change in one or more elements

RS—a scheduled record observation that also qualifies as a special observation.

All three types of observations (SA, SP, RS) are followed by a 24 hour-clock-time-group in GMT.

U.S. DEPARTMENT OF COMMERCE — NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION — NATIONAL WEATHER SERVICE

KEY TO AVIATION WEATHER FORECASTS . . . .

TERMINAL FORECASTS contain information for specific airports on expected ceiling, cloud heights, cloud amounts, visibility, weather, and obstructions to vision and surface wind. They are issued 3 times/day and are valid for 24 hours. The last six hours of each forecast are covered by a categorical statement indicating whether VFR, MVFR, IFR or LIFR conditions are expected (L in LIFR and M in MVFR indicate "low" and "marginal"). Terminal forecasts will be written in the following form:

CEILING: Identified by the letter "C"

CLOUD HEIGHTS: In hundreds of feet above the station (ground)

CLOUD LAYERS: Stated in ascending order of height

VISIBILITY: In statute miles but omitted if over 6 miles

WEATHER AND OBSTRUCTION TO VISION: Standard weather and obstruction to vision symbols are used

SURFACE WIND: In tens of degrees and knots; omitted when less than 10

EXAMPLE OF TERMINAL FORECAST

221010: DCA Forecast 22nd day of month—valid time 10Z–10Z.

10 SCT C18 BKN 5SW–3415G25 OCNL C8 X 1/2SW: Scattered clouds at 1000 feet, ceiling 1800 feet broken, visibility 5 miles, light snow showers, surface wind 340 degrees 15 knots Gusts to 25 knots, occasional ceiling 8 hundred feet sky obscured, visibility ½ mile in moderate snow showers.

12Z C50 BKN 3312G22: At 12Z becoming ceiling 5000 feet broken, surface wind 330 degrees 12 knots Gusts to 22.

04Z MVFR CIG: Last 6 hours of FT after 04Z marginal VFR due to ceiling.

AREA FORECASTS are 18-hour aviation forecasts plus a 12-hour categorical outlook prepared 2 times/day giving general descriptions of cloud cover, weather and frontal conditions for an area the size of several states. Heights of cloud tops, and icing are referenced ABOVE SEA LEVEL (ASL); ceiling heights, ABOVE GROUND LEVEL (AGL); bases of cloud layers are ASL unless indicated. Each SIGMET or AIRMET affecting an FA area will also serve to amend the Area Forecast.

SIGMET or AIRMET messages broadcast by FAA on NAVAID voice channels warn pilots of potentially hazardous weather. SIGMET concerns severe and extreme conditions of importance to all aircraft, (i.e. icing, turbulence, and duststorms/sandstorms). Convective SIGMETS are issued for thunderstorms by the Severe Storms Forecast Center at Kansas City for the conterminous U.S. AIRMETS concern less severe conditions which may be hazardous to some aircraft or to relatively inexperienced pilots.

WINDS AND TEMPERATURES ALOFT (FD) FORECASTS are 12-hour forecasts of wind direction (nearest 10° true N) and speed (knots) for selected flight levels. Temperatures aloft (°C) are included for all but the 3000-foot level.

EXAMPLES OF WINDS AND TEMPERATURES ALOFT (FD) FORECASTS:

FD WBC 121745
BASED ON 121200Z DATA
VALID 130000Z FOR USE 1800-0300Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
BOS	3127	3425-07	3420-11	3421-16	3516-27	3512-38	311649	292451	283451
JFK	3026	3327-08	3324-12	3322-16	3120-27	2923-38	284248	285150	285749

At 6000 feet ASL over JFK wind from 330° at 27 knots and temperature minus 8°C.

TWEB (CONTINUOUS TRANSCRIBED WEATHER BROADCAST)—Individual route forecasts covering a 25-nautical-mile zone either side of the route. By requesting a specific route number, detailed en route weather for a 12- or 18-hour period (depending on forecast issuance) plus a synopsis can be obtained.

PILOTS . . . report inflight weather to nearest FSS. The latest surface weather reports are available by phone at the nearest pilot weather briefing office by calling at H+10.

U.S. DEPARTMENT OF COMMERCE — NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION — NATIONAL WEATHER SERVICE —REVISED OCTOBER 1978

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GPO : 1978 O - 277-321

SA 0050 CLR 15 279/32/7/2007/034/ 607 43 (DR 05:49Z)
SY 72206 32974 02007 10000 21139 30113 40279 56007 333 10061 21022 70000 555 91706= (DR05:50Z)

SA 0150 CLR 15 279/30/9/2207/034 (DR 06:50Z)
SA 0250 CLR 15 277/31/11/2110/034/ 98585 (DR 07:49Z)
SA 0350 CLR 15 276/31/9/2207/033/ 003 (DR 08:49Z)
SA 0450 CLR 15 271/31/10/2105/032 (DR 09:50Z)
SA 0550 CLR 15 270/21/10/2105/031 (DR 10:51Z)
SA COR 0550 CLR 15 269/31/10/2105/031 (DR 11:07Z)
SA 0650 CLR 15 268/30/11/2005/031/ 608 29 (DR 11:50Z)
SY 72206 32974 02005 11011 21117 30102 40268 56008 333 10061 21017 555 91712= (DR11:51Z)

SA 0750 250 SCT 15 270/30/13/2007/031 (DR 12:50Z)
SA 0850 200 SCT 15 262/36/15/2108/029 (SWS 13:50Z)
SA 0950 250 SCT 15 258/41/15/1213/028/ 908 1001 (SWS 14:50Z)
SA COR 0950 250 SCT 15 258/41/15/2113/028/ 808 1001 (SWS 15:51Z)
SA 1050 CLR 15 249/46/17/2209/026 (SWS 15:52Z)
SA 1151 CLR 15 230/52/19/2314/020/WND 20V27 (SWS 16:51Z)
SA 1250 CLR 15 212/55/20/2310/015/ 744 29 (SWS 17:50Z)
SY 72206 32974 02310 10128 21067 30049 40212 57044 333 10128 21017 555 91718= (SWS17:50Z)

SA 1352 CLR 15 198/57/21/2416G23/011 (SWS 18:52Z)
SA 1453 CLR 15 195/58/22/2417/010 (SWS 19:53Z)
SA 1551 CLR 15 190/58/22/2213/008/ 722 (SWS 20:50Z)
SA 1653 CLR 15 192/55/22/2309/009 (PB 21:51Z)
SA 1750 CLR 15 201/52/21/2208/011 (PB 22:47Z)
SA 1850 CLR 15 197/52/21/2008/011/ 007 58 (PB 23:48Z)
SY 72206 32974 02008 10111 21061 30034 40197 50007 333 10144 21017 555 91800= (PB23:49Z)

SA 1951 CLR 15 201/51/21/2210/012 (PB 00:49Z)
SA 2050 CLR 15 202/49/22/2209/012 (PB 01:48Z)
SA 2151 CLR 15 205/45/22/2206/013/ 208 (PB 02:49Z)
SA 2250 CLR 15 205/43/24/2208/013 (PB 03:48Z)
SA 2350 CLR 10 205/43/22/2206/013 (DR 04:53Z)

0050	29.865	33.0	0			0 5	00.00
0150	29.865	33.0	0			0	00.00
0250	29.860	31.0	0			0	00.00
0350	29.855	31.0	0			0 8	00.00
0450	29.840	31.0	0			0	00.00
0550	29.835	31.0	0			0	00.00
0650	29.830	30.0	0			0 6	00.00
0750	29.835	30.0	1	1CI	250	1	00.00
0850	29.815	36.0	1	1CI	200	1	00.00
0950	29.805	41.0	1	1CI	250	1 8	00.00
1050	29.780	46.0	0			0	00.00
1151	29.725	52.0	0			0	00.00
1250	29.675	55.0	0			0 7	00.00
1352	29.635	57.0	0			0	00.00
1453	29.625	58.0	0			0	00.00
1551	29.610	58.0	0			0 7	00.00
1653	29.615	55.0	0			0	00.00
1750	29.640	52.0	0			0	00.00
1850	29.630	52.0	0			0 0	00.00
1951	29.640	51.0	0			0	00.00
2050	29.645	49.0	0			0	00.00
2151	29.655	45.0	0			0 2	00.00
2250	29.655	43.0	0			0	00.00
2350	29.655	43.0	0			0	00.00

Synoptic Observations

MID1	0.00	.0		33	32		
0050	0.00	.0	0	35	32	29.865	.000
0650	0.00	.0	0	32	29	29.830	.000
1250	0.00	.0	0	55	30	29.685	-.010
1850	0.00	.0	0	58	52	29.625	+.005
MID2	0.00	.0	0	52	43		

Summary of Day (midnight to midnight)

Max Temp	Min Temp	Precip (Ins.)	Snow Fall	Snow Depth	[Peak Wind] Speed/Dir Time	Sky Cover s/s	Sky Cover s/e	Water Equiv.	Fastest Wind
58	29	00.00	.0	0	26SW 1335	0	0		21 23 1250

Sunrise: 0719 Sunset: 1703 Total Sunshine: 584 % Psbl: 100 Character of Sunrise/Sunset: CLEAR CLEAR

Weather & Obstructions to Vision

Remarks, Notes and Miscellaneous Phenomena

TIME CHECK== 0117 // SG CHART CHANGED 1255E

SA 0050 CLR 15 346/29/10/3510/054/ 225 51 (SGY 05:53Z)
SY 72306 32974 03510 11017 21122 30179 40346 52025 333 10106 21017 70000 555 91906= (SGY05:54Z)

SA 0150 CLR 15 354/28/9/3411/057 (SGY 06:50Z)
SA 0253 CLR 15 365/27/9/3409/060/ 98584 (SGY 07:53Z)
SA 0354 CLR 15 370/26/8/3412/061/ 124 (SGY 08:54Z)
SA 0450 CLR 15 377/25/8/3308/063 (SGY 09:50Z)
SA 0550 CLR 15 392/24/8/3506/068 (SGY 10:51Z)
SA 0650 CLR 15 401/23/8/3208/070/ 329 23 (SGY 11:52Z)
SY 72306 32974 03208 11050 21133 30232 40401 53029 333 10106 21050 555 91912= (SGY11:53Z)

SA 0752 CLR 15 409/25/8/3608/072 (SGY 12:52Z)
SA 0852 CLR 15 420/27/8/3410/075 (JM 13:52Z)
SA 0950 CLR 15 428/31/5/3617/078/ 127 (JM 14:50Z)
SA 1054 CLR 15 430/33/-2/0119/079 (JM 15:54Z)
SA 1153 CLR 15 426/36/-2/3613/077 (JM 16:54Z)
SA 1250 CLR 15 421/37/-1/3614/076/ 007 23 (JM 17:49Z)
SY 72306 32974 03614 10028 21103 30252 40421 50007 333 10028 21050 555 91918= (JM17:50Z)

SA 1350 CLR 15 419/38/-1/3613620/075 (JM 18:49Z)
SA 1450 CLR 15 419/38/-2/0115/075 (JM 19:49Z)
SA 1550 CLR 15 421/38/-3/0212/076/ 500 (JM 20:47Z)
SA 1653 CLR 15 430/35/-3/0209/078 (PB 21:51Z)
SA 1752 CLR 15 437/32/-3/3606/080 (PB 22:51Z)
SA 1850 CLR 15 439/31/-2/0206/081/ 217 30 (PB 23:49Z)
SY 72306 32974 00206 11006 21189 30269 40439 52017 333 10033 21050 555 92000= (PB23:51Z)

SA 1950 CLR 15 443/26/0/0404/082 (PB 00:48Z)
SA 2052 CLR 15 446/26/1/0206/083/FEW THN CI (PB 01:51Z)
SA 2151 CLR 15 446/27/0/0305/083/ 107 (PB 02:50Z)
SA 2250 CLR 15 442/24/4/0003/082 (PB 03:48Z)
SA 2353 CLR 15 442/25/3/3104/082 (PB 04:51Z)

[illegible]

0050	30.060	29.0		0			0 2	00.00
0150	30.085	28.0		0			0	00.00
0253	30.115	27.0		0			0	00.00
0354	30.130	26.0		0			0 1	00.00
0450	30.150	25.0		0			0	00.00
0550	30.190	24.0		0			0	00.00
0650	30.215	23.0		0			0 3	00.00
0752	30.240	25.0		0			0	00.00
0852	30.270	27.0		0			0	00.00
0950	30.295	31.0		0			0 1	00.00
1054	30.300	33.0	-2.1	0			0	00.00
1153	30.290	36.0	-2.1	0			0	00.00
1250	30.275	37.0	-1.1	0			0 8	00.00
1350	30.270	38.0	-1.1	0			0	00.00
1450	30.270	38.0	-2.1	0			0	00.00
1550	30.275	38.0	-3.1	0			0 5	00.00
1653	30.300	35.0	-3.1	0			0	00.00
1752	30.320	32.0	-3.1	0			0	00.00
1850	30.325	31.0	-2.1	0			0 2	00.00
1950	30.335	26.0		0			0	00.00
2052	30.345	26.0		0	0CI	250	0	00.00
2151	30.345	27.0		0			0 1	00.00
2250	30.335	24.0		0			0	00.00
2353	30.335	25.0		0			0	00.00

Synoptic Observations

MID1	0.00	.0		30	29	
0050	0.00	.0	0	39	29	30.070 -.010
0650	0.00	.0	0	29	23	30.220 -.005
1250	0.00	.0	0	37	23	30.290 -.015
1950	0.00	.0	0	38	31	30.345 -.020
MID2	0.00	.0	0	31	23	

Summary of Day (midnight to midnight)

Max Temp	Min Temp	Precip (Ins.)	Snow Fall	Snow Depth	[Peak Wind] Speed/Dir	Time	Sky Cover s/s	m/m	Water Equiv.	Fastest Wind
38	23	00.00	.0	0	24N	1156	0	0		22 1 1054

Sunrise: 0720 Sunset: 1704 Total Sunshine: 584 % Psbl: 100 Character of Sunrise/Sunset: CLEAR CLEAR

Weather & Obstructions to Vision

Remarks, Notes and Miscellaneous Phenomena

TIME CHECK== 0054 // PEAK WIND WAS THE LAST OF SEVERAL OCCURRENCES

```
SA 0050 CLR 15 442/22/3/3305/002/ 503 38 (SWS 05:54Z)
SY 72306 32974 03305 11056 21161 30273 40442 55203 333 10033 21067 70000 555 92006= SWS05:54Z)

SA 0150 CLR 15 442/22/4/3306/002/FEW CI (SWS 06:53Z)
SA 0251 250 -SCT 15 442/20/5/0104/002/ 98584 (SWS 07:53Z)
SA 0351 250 -SCT 15 439/18/8/0303/001/ 003 1001 (SWS 08:53Z)
SA 0450 CLR 15 441/18/7/3205/001/FEW CI (SWS 09:51Z)
SA 0550 CLR 15 445/16/7/0504/003/FEW CI (SWS 10:52Z)
SA 0650 CLR 15 450/16/7/3603/004/ 110 14 (SWS 11:55Z)
SY 72306 32974 03603 11009 21139 30279 40450 51010 333 10033 21100 555 92012= (SWS11:55Z)

SA 0752 CLR 15 456/15/7/1503/005 (SWS 12:54Z)
SA 0854 CLR 15 459/24/10/2004/007 (JM 13:55Z)
SA 0954 250 -SCT 15 449/32/9/2603/004/ 000 1001 (JM 14:55Z)
SA 1053 250 -SCT 15 449/36/4/2004/004 (JM 15:54Z)
SA 1150 250 -SCT 15 438/41/0/3404/001 (JM 16:58Z)
SA 1253 250 -BKN 15 423/44/1/2206/076/ 825 1006 14 (JM 17:55Z)
SY 72306 32974 62206 10067 21172 30254 40423 58025 80006 333 10067 21120 555 92018= (JM17:56Z)

SA 1350 250 -BKN 15 414/45/-2/2706/074 (JM 18:50Z)
SA 1452 200 SCT E250 BKN 15 407/46/-3/2608/072 (JM 19:53Z)
SA 1558 180 SCT E250 OVC 15 402/45/1/2006/070/ 620 1057 (JM 20:51Z)
SA 1654 120 SCT 250 -BKN 15 401/44/0/2104/070 (SGY 21:55Z)
SA 1752 E150 BKN 250 OVC 15 403/42/3/2005/070 (SGY 22:53Z)
SA 1850 120 SCT E150 OVC 15 396/40/4/1605/069/BINOVC/ 707 107/ 47 (SGY 23:53Z)
SY 72306 32974 71605 10044 21156 30227 40396 57007 87070 333 10003 21100 555 92100= (SGY23:54Z)

SA 1952 E120 BKN 150 OVC 15 396/39/10/2405/068 (SGY 00:52Z)
SA 2050 E120 OVC 15 392/40/5/2006/067/THN SPTS 1OVC (SGY 01:51Z)
SA 2151 E120 OVC 15 377/40/5/2107/063/BINOVC/ 717 107/ (SGY 02:53Z)
SA 2250 120 SCT 250 -BKN 15 367/38/5/1906/060 (SGY 03:50Z)
SA 2354 E120 BKN 250 BKN 15 356/37/7/2207/057 (SGY 04:54Z)
```

0050	[illegible]	[illegible]		0						0 5	20.00
0150	30.335	22.0		0	0CI	250				0	20.00
0251	30.335	20.0		3	3CI	250				1	00.00
0351	30.335	19.0		3	3CI	250				1 0	20.00
0452	30.330	15.0		0	0CI	250				0	00.00
0552	30.340	16.0		0	0CI	250				0	00.00
0650	30.355	16.0		0						0 1	00.00
0752	30.370	15.0		0						0	00.00
0854	30.380	24.0		0						0	00.00
0954	30.355	32.0		3	3CI	250				0 0	00.00
1053	30.355	36.0		4	4CI	250				0	00.00
1150	30.325	41.0		4	4CI	250				1	00.00
1253	30.280	44.0		7	7CI	250				3 0	00.00
1350	30.255	45.0	-2.1	8	8CI	250				3	00.00
1452	30.235	46.0	-3.1	9	1CC	200	8CS	250	9	5	00.00
1550	30.220	45.0		10	1AC	180	10CS	250	10	8 6	00.00
1654	30.215	44.0		9	1AC	120	8CS	250	9	2	00.00
1752	30.220	42.0		10	6AC	150	4CS	250	10	7	00.00
1850	30.200	40.0		10	2AC	120	8AC	150	10	10 7	00.00
1952	30.200	39.0		10	7AC	120	3AC	150	10	10	00.00
2050	30.190	40.0		10	10AC	120				10	00.00
2151	30.150	40.0		10	10AC	120				10 7	00.00
2250	30.120	38.0		6	3AC	120	3CI	250	6	3	00.00
2354	30.090	37.0		8	6AC	120	2CI	250	8	6	00.00

Synoptic Observations

MID1	0.00	.0		25	20		
0050	0.00	.0	0	31	20	30.360	-.025
0650	0.00	.0	0	22	14	30.375	-.020
1253	0.00	.0	0	44	14	30.295	-.015
1350	0.00	.0	0	47	30	30.210	-.010
MID2	0.00	.0	0	41	36		

Summary of Day (midnight to midnight)

Max Temp	Min Temp	Precip (ins.)	Snow Fall	Snow Depth	[Peak Wind] Speed/Dir	Time	Sky Cover s/s	m/m	Water Equiv.	Fastest Wind
47	14	00.00	.0	0	10W	1448	5	5		5 25 1452

Sunrise: 0721 Sunset: 1705 Total Sunshine: 429 % Posbl: 73 Character of Sunrise/Sunset: CLEAR CLOUDY

Weather & Obstructions to Vision

Remarks, Notes and Miscellaneous Phenomena

TIME CHECK== 0256 //

RS 0251 M65 OVC 15 308/41/34/3606/041/BINOVC FEW LWR SC 9 HND / 714 15// 52 (PB 05:54Z)
S 72206 32474 73606 12058 20011 30125 40300 57014 87520 333 10111 20017 70000 555 90206= (PB05:55Z)

SA 0150 8 -BKN M65 BKN 15 294/40/34/0206/040/LWR SC MOVG SW (PB 06:50Z)
SA 0251 7 SCT 65 SCT 15 294/39/34/0106/039/ 98103 (PB 07:51Z)
SA 0352 65 SCT 15 289/38/34/0106/039/SC MSTLY W-NE/ 710 1500 (PB 08:57Z)
SA 0454 CLR 15 288/38/34/0205/038/FEW SC (PB 09:55Z)
0552 CLR 10 289/37/34/0106/037 (PB 10:53Z)
0650 7 -BKN 7 287/35/33/0405/037/ST INCG/ 703 1600 35 (PB 11:51Z)
7306 33361 60405 10017 20006 30122 40287 57003 86600 333 10111 20017 555 90212= (PB11:52Z)

M4 OVC 7 0405/037/THN SPTS IOVC (PB 12:03Z)
M4 OVC 3F 0505/037/VSBY LWR NE-S (PB 12:40Z)
M4 OVC 11/2F 288/39/37/0306/037/SFC VSBY 3 SFC CIG AND VSBY LWR N-SW (PB 12:51Z)
+ M3 OVC 1/2F 0305/037/R05RVR55V60+ SFC VSBY 1 1/2 (MR 13:04Z)
0 W2 X 1/16F 0305/036/R05RVR18V50 SFC VSBY 1/4 (MR 13:21Z)
026 W1 X 1/16F 0505/036/R05RVR10V40 SFC VSBY 1/4 (MR 13:27Z)
0850 W1 X 0F 285/39/39/0505/036/R05RVR10- SFC VSBY 1/4 (MR 13:50Z)
0950 W1 X 0F 285/40/40/0406/037/R05RVR16V24 SFC VSBY 1/4/ 802 (MR 14:50Z)
1052 W2 X 1/4F 278/43/42/0607/034/R23R35V60 SFC VSBY 5/8 (MR 15:52Z)
1103 M3 OVC 1/2F 0306/033/R23R60V60+ SFC VSBY 3/4 (MR 16:03Z)
P 1106 M3 OVC 1F 0306/033/R23R60+ (MR 16:06Z)
1123 M4 OVC 21/2F 0207/032 (MR 16:24Z)
SP 1135 M5 OVC 21/2F 0207/032 (MR 16:35Z)
SP 1139 M5 OVC 3F 0107/031/SUN DMLY VSB (MR 16:38Z)
SA 1150 M7 OVC 3F 264/48/43/0106/031/SFC VSBY 6 THN SPTS IOVC (MR 16:51Z)
SP 1202 8 SCT 110 SCT E250 OVC 7 3607/000/THN SPTS IOVC (MR 17:03Z)
SA 1250 110 SCT E250 OVC 7 258/51/43/3606/029/FEW ST 9 HND THN SPTS IOVC/ 725 1671 35 (MR 17:49Z)
SY 72306 31461 03606 10106 20061 30095 40258 57025 70242 81671 333 10106 20017 555 90218= (MR17:51Z)

SA 1350 120 SCT E250 OVC 7 244/53/43/3606/025/SUN DMLY VSB (MR 18:49Z)
SA 1450 E120 BKN 250 OVC 7 236/54/44/0109/023/FEW LWR AC (MR 19:52Z)
SA 1550 120 SCT E250 OVC 7 229/54/45/3607/020/ 729 1078 (MR 20:52Z)
SA 1650 E120 BKN 200 OVC 7 222/52/45/0209/018 (JM 21:52Z)
SA 1750 120 SCT E200 OVC 7 221/50/44/0407/018 (JM 22:50Z)
SA 1850 E120 BKN 200 OVC 7 219/50/45/0507/017/ 610 1027 55 (JM 23:54Z)
SY 72306 32961 80507 10100 20072 30056 40219 56010 85027 333 10128 20017 555 90300= (JM23:55Z)

SA 1950 M120 OVC 7 215/50/46/0607/016 (JM 00:53Z)
SP 2043 M13 BKN 120 OVC 7 0509/015 (JM 01:46Z)
SA 2052 M11 OVC 7 209/50/47/0607/014 (JM 01:52Z)
SP 2109 M9 OVC 7 0508/014 (JM 02:12Z)
SA 2151 M7 OVC 7 209/51/48/0608/014/ 610 16// (JM 02:53Z)
RS 2255 M3 OVC 7 208/51/49/0608/014 (JM 04:00Z)
RS COR 2255 M3 OVC 7 199/51/49/0608/011 (JM 04:10Z)
SP 2309 M3 OVC 11/2F 0609/011/R05RVR60+ SFC VSBY 3 (JM 04:11Z)
SA 2351 M3 OVC 11/2F 190/51/50/0609/009/R05RVR60+ L605 (JM 04:57Z)

0051	29.920	41.0	10	0SC	9	10SC	35	10				10 7	00.00
0158	29.915	40.2	7	6SC	9	1SC	35	7				4	00.00
0251	29.915	37.0	5	5SC	7	0SC	35	5				5	00.00
0350	29.908	33.0	5	5SC	35							4 7	00.00
0454	29.895	33.0	0	0SC	35							0	00.00
0552	29.895	33.0	0									0	00.00
0650	29.898	35.0	9	9ST	7							4 7	00.00
0750	29.895	39.0	10	10ST	4							10	00.00
0850	29.885	39.0	10	10F	1							10	00.00
0950	29.885	42.0	10	10F	1							10 8	00.00
1052	29.865	45.0	10	10F	2							10	00.00
1150	29.825	48.0	10	10ST	7							10	00.00
1250	29.810	51.0	10	0ST	9	3AC	110	3	7CI	250	10	7 7	00.00
1350	29.770	53.0	10	4AC	120	6CI	250	10				7	00.00
1450	29.745	54.0	10	0AC	80	6AC	120	6	4CI	250	10	9	00.00
1550	29.725	54.0	10	5AC	120	5CS	250	10				10 7	00.00
1650	29.705	53.0	10	6AS	120	10CS	200	10				10	00.00
1750	29.700	52.0	10	5AS	120	10CS	200	10				10	00.00
1850	29.695	50.0	10	6AS	120	10CS	200	10				10 6	00.00
1950	29.685	50.0	10	10AS	120							10	00.00
2050	29.665	50.0	10	10SC	11							10	00.00
2151	29.665	51.0	10	10ST	7							10 6	00.00
2255	29.640	51.0	10	10ST	3							10	00.00
2351	29.615	51.0	10	10ST	3							10	T

Synoptic Observations

MID1	0.00	.0		41	41		
0051	0.00	.0	0	46	41	29.940	-.010
0650	0.00	.0	0	41	35	29.900	-.010
1250	0.00	.0	0	51	35	29.810	.000
1850	0.00	.0	0	55	49	29.695	.000
MID2	T	.0	0	51	50		

Summary of Day (midnight to midnight)

Max Temp	Min Temp	Precip (Ins.)	Snow Fall	Snow Depth	(Peak Wind) Speed/Dir Time	Sky Cover s/s	a/m	Water Equiv.	Fastest Wind
55	35	T	.0	.0	15NE 2257	10	9		10 6 2351

Sunrise: 0725 Sunset: 1713 Total Sunshine: 0 % Psbl: 0 Character of Sunrise/Sunset: CLOUDYCLOUDY

Weather & Obstructions to Vision

F+ 0735 1158 F 2301 CONT L- 2305 CONT

Remarks, Notes and Miscellaneous Phenomena

TIME CHECK== 0756 // NCDC// RS 0750 REMARKS SHOULD BE: SFC VSBY 3 CIG AND VSBY LWRG ... SA 0850 SHOULD BE RS ... SA 0950 SHOULD BE RS ... RS 1052 R23R35V60 SHD BE R23RVR35V60 ... SP 1103 R23R60V60+ SHD BE R23RVR60V60+ ... SP 1106 R23R60+ SHD BE R23RVR60+ // USING R23R RVR INSTEAD OF R05R AT TOWERS REQUEST FROM 1030E - 1115E // FASTEST ONE MINUTE WIND SPEED WAS THE LAST OF SEVERAL OCCURRENCES

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SA 0258 E250 BKN 15 118/43/38/2604/989/ 603 1008 57 (SGY 05:56Z)
SY 72306 32974 72604 10061 22033 39959 40119 56003 90208 333 10139 22256 72208 555 90606= (SGY05:56Z)

SA 0155 E250 BKN 15 120/42/37/0107/988 (SGY 07:01Z)
SA 0252 E250 BKN 15 120/41/38/0506/989/ 98001 (SSY 07:56Z)
SA 0350 E250 BKN 15 117/40/38/0605/987/ 902 1008 (SGY 08:52Z)
SA 0452 E250 OVC 15 117/39/37/0605/987 (SGY 09:53Z)
SA 0558 47 SCT 100 SCT E250 OVC 12 124/39/36/0504/989/FEW LWR SC (SGY 10:58Z)
SA 0651 100 SCT E250 OVC 10 125/38/36/0405/989/FEW SC/ 107 1577 38 (SGY 11:54Z)
SY 72306 32566 80405 10033 20022 39963 40125 51007 81577 333 10139 20033 555 90612= (SGY11:55Z)

SA 0750 E120 BKN 250 OVC 10 126/39/35/0204/990/FEW SC (SGY 12:51Z)
SA 0850 E130 BKN 200 BKN 250 OVC 8 128/41/36/0505/991/THN SPTS IOVC (MR 13:50Z)
SA 0950 120 SCT E200 BKN 250 OVC 8 133/43/35/0607/992/NMRS BINOVC/ 208 1078 (MR 14:52Z)
SA 1050 120 SCT E190 BKN 250 OVC 10 129/47/35/0709/991/THN SPTS IOVC OCNL SUN (MR 15:51Z)
SA 1150 19 SCT E140 BKN 200 OVC 10 122/49/36/0904/989/SUN DMLY VSB (MR 16:49Z)
RS 1250 M20 BKN 45 BKN 120 OVC 10 117/49/36/2704/987/20 BKN V SCT/ 815 157/ 32 (MR 17:58Z)
SY 72306 32566 82704 10094 20022 39956 40117 58015 8657/ 333 10100 20033 555 90618= (MR17:58Z)

SP 1307 20 SCT M43 BKN 120 OVC 10 2804/986 (MR 18:08Z)
SA 1350 45 SCT E120 OVC 10 108/50/37/3203/985/FEW LWR SC SML BINOVC (MR 18:49Z)
SA 1450 45 SCT 95 SCT E130 OVC 10 109/49/37/3606/985 (MR 19:49Z)
SA 1550 85 SCT E130 BKN 250 OVC 10 112/48/36/3405/986/THN SPTS IOVC/ 505 1071 (MR 20:50Z)
SA 1650 E130 BKN 10 118/47/37/0204/987/SUN DOG W (PB 21:50Z)
SA 1750 E130 BKN 250 BKN 10 125/44/38/0000/989 (PB 22:49Z)
SA 1852 130 SCT 250 -BKN 10 129/41/38/0000/990/ 215 1071 51 (PB 23:51Z)
SY 72306 32966 60000 10050 20033 39966 40129 52015 83071 333 10106 20033 555 90700= (PB23:52Z)

SA 1954 160 SCT 250 SCT 10 129/38/37/0000/990 (PB 00:53Z)
SA 2053 250 -SCT 7 134/36/35/0000/992/F FRMG SW-W (PB 01:52Z)
SA 2150 250 -SCT 7 141/37/34/0000/994/ 312 1081 (PB 02:49Z)
SA 2250 CLR 7 142/37/33/3404/994 (PB 03:51Z)
SA 2350 CLR 7 143/37/38/3204/995 (PB 04:58Z)
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425	[illegible]	[illegible]	9CS	250									5 5	00.00
.0	40.0	9	9CS	250									5	00.00
410	41.0	8	9CS	250									5	00.00
400	40.0	8	9CS	250									5 8	00.00
400	39.0	10	10CS	250									8	00.00
20	39.0	10	0SC	21	2SC	47	2	2AC	100	4	6CS	250 10	7	00.00
420	39.0	10	0SC	21	0SC	47	0	3AC	100	3	7CS	250 10	8 1	00.00
425	39.0	10	0SC	45	7AC	120	7	1CS	250 10				10	00.00
400	41.0	10	6AC	130	2CS	200	8	2CI	250 10				8	00.00
445	43.0	10	4AC	120	4CS	200	8	2CI	250 10				8 2	00.00
475	47.0	10	3AC	120	5CS	190	8	2CI	250 10				9	00.00
415	45.0	10	3SC	19	6AC	140	9	1CS	200 10				10	00.00
400	49.0	10	6SC	20	2SC	45	8	2AC	120 10				10 8	00.00
475	50.0	10	0SC	20	4SC	45	4	6AC	120 10				10	00.00
475	49.0	10	2SC	45	2AC	95	4	6AC	130 10				10	00.00
435	49.0	10	2AS	85	6AC	130	9	2CI	250 10				8 5	00.00
400	47.0	9	9AC	130									9	00.00
400	44.0	9	9AC	130	0CI	250	9						9	00.00
400	41.0	8	4AC	130	4CI	250	8						4 2	00.00
430	38.0	5	2AC	160	3CI	250	5						5	00.00
445	36.0	4	4CI	250									2	00.00
465	37.0	2	2CI	250									1 3	00.00
470	37.0	0											0	00.00
475	37.0	0											0	00.00

ic Observations

0	.0		46	43		
0	.0	0	48	42	29.405	.000
0	.0	0	44	38	29.410	+.010
0	.0	2	50	38	29.395	+.005
0	.0	0	51	41	29.430	.000
0	.0	0	41	36		

Day (midnight to midnight)

Precip Ins.	Snow Fall	Snow Depth	[Peak Wind] Speed/Dir	Time	Sky Cover s/s	m/m	Water Equiv.	Fastest Wind
00.00	.0	0	13N	2208	10	9		10 7 1050

725 Sunset: 1716 Total Sunshine: 13 % Psbl: 2 Character of Sunrise/Sunset: CLOUDYCLOUDY

Obstructions to Vision

hers and Miscellaneous Phenomena

== 2038 /