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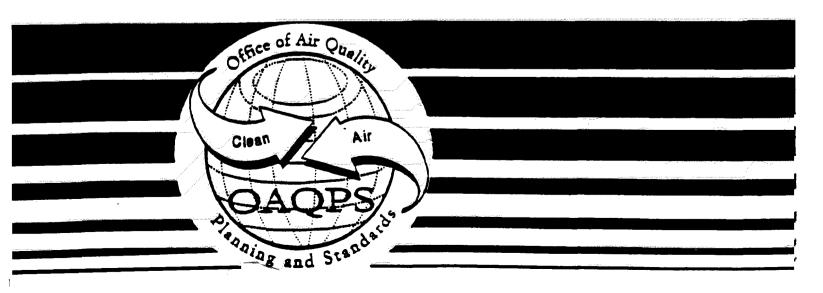
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Lime Manufacturing Industry Fourier Transform Infrared Spectroscopy

Chemical Lime Marble Falls, Texas



Lime Kiln Source Characterization Final Report

Contract No. 68-D7-0007 Work Assignment 1-08

Chemical Lime Company Marble Falls, Texas

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1.0 INTRODUCTION

The purpose of this testing program is to obtain uncontrolled and controlled hydrogen chloride (HCl) and speciated hydrocarbon Hazardous Air Pollutants (HAPs) emissions data from lime production plants to support a national emission standard for hazardous air pollutants (NESHAP).

Three measurement methods were conducted at this facility:

- Fourier Transform Infrared Spectroscopy (FTIR) (EPA Draft Method 320);
- Gas Filter Correlation Infrared (GFC-IR) (EPA Method 322); and
- Dioxin/furan manual trains (EPA Method 23).

This report presents data from the FTIR measurements. EPA Method 23, 25A, and 322 measurements were conducted by Pacific Environmental Services, Inc. (PES), and Air Pollution Characterization and Control, Ltd.(APCC), under subcontract to PES, respectively. Process data was collected by Research Triangle Institute, Inc. (RTI), under contract to EPA. Please refer to the report prepared by PES for information and results of the Method 23, 25A, and 322 testing.

FTIR source testing was conducted for the following purposes:

- Quantify HCl emission levels; and
- Gather screening (i.e., qualitative) data on other HAP emissions.

The lime kiln facility and sampling locations that were tested in the program are detailed in the report prepared by PES.

1.1 Objectives

The objective of the FTIR testing of the lime facility was to perform quantitative measurement of hydrogen chloride (HCl) and screening of other HAPs detectable by FTIR, using EPA Draft Method 320.

1.2 Brief Site Discussion

Testing was conducted at the Chemical Lime Company located in Marble Falls, Texas. Testing was performed on the inlet and outlet of a fabric-filter baghouse on Kiln #1, a double-shaft vertical kiln. Detailed site information can be found in the report prepared by PES.

1.3 Emissions Measurements Program

This section provides an overview of the emissions measurement program conducted at the Chemical Lime Company, located in Marble Falls, Texas. Included in this section are summaries of the test matrix, test schedule, and authorized deviations from the test plan.

Additional detail on these topics are provided in the sections that follow.

1.3.1 Test Matrix

The complete sampling and analytical matrix that was performed is presented in the report prepared by PES. In this report, only FTIR-related test matrix will be provided. FTIR spectroscopy was used, in accordance with EPA Draft Method 320, to quantify HCl and also, in a screening capacity, to measure other HAPs that can be detected by FTIR.

FTIR measurements were conducted in two sets:

- Unconditioned; and
- Conditioned.

Unconditioned sampling was conducted during the extent of the EPA Method 23 dioxin manual train runs. These runs were approximately 3 hours in duration. After completion of a dioxin run, the FTIR measured conditioned sample gas for a one-hour period to screen for aromatic species such as benzene, toluene, etc. At this particular site, the conditioned run was conducted prior to the unconditioned run.

During each run (i.e., unconditioned or conditioned) the FTIR analysis time was divided equally between inlet and outlet samples. Each location was monitored for no less than a total of 90 minutes. Some data points (typically, 5 minutes) were discarded for each set due to inlet/outlet sample mixing in the FTIR analysis cell. The actual amount of data points discarded is given later in this report. This procedure ensures the remaining data points were data truly representing the location being tested in that set.

1.3.2 Test Schedule

The test schedule for EPA Method 23 and 322 measurements is given by the report prepared by PES. Section 2.1 gives the test log for the FTIR testing at this site.

1.3.3 Deviations from Test Plan/Schedule

Deviations from the original FTIR Site-Specific Test Plan (SSTP) are listed below:

- Testing was originally planned for 15 minute intervals between the inlet and outlet. The measurements consisted of collecting 24 minute intervals at the outlet and inlet, in order to synchronize with the process cycle time and GFC-IR measurements performed by APCC.
- The EPA Work Assignment Manager authorized one hour total sample collection of the conditioned samples, ½ hour each on inlet and outlet. If detection of other HAPs was determined, then the run would extend to the full two hours, as originally planned. In this case, no additional HAPs were detected in the conditioned samples.

1.4 Test Report

This final report, presenting all data collected and the results of the analyses, has been prepared in four sections, and six appendices as described below:

- Section 1 provides an introduction to the testing effort and includes a brief description of the test site and an overview of the emissions measurements program;
- Section 2 gives a summary of the test results for the FTIR results for HCl and other detected species;
- Section 3 presents detailed descriptions of the sampling and analysis procedures; and;
- Section 4 provides details of the quality assurance/quality control procedures used on this program and the QC results.

A detailed description of the site, sampling locations, process and plant operation during the field test is provided in the PES-prepared report. Copies of the field data sheets and raw FTIR concentration data are contained in the appendices.

Seven appendices are found in this report. They are organized as follows:

- Appendix A contains spreadsheet QA/QC review sheets;
- Appendix B contains QC gas cylinder certification sheets;
- Appendix C contains raw FTIR data;
- Appendix D contains FTIR field data sheets;
- Appendix E contains pre-test calculations; and
- Appendix F contains post-test calculations.

2.0 SUMMARY OF RESULTS

This section provides the FTIR results of the emissions test program conducted at the Chemical Lime Company in Marble Falls, Texas on June 25, 1998. Results for the extractive FTIR test conducted for HCl and screening for selected HAPs are provided in this section. Other (non-HAP) species which were detected are also reported. Testing was performed at the inlet and outlet of the baghouse.

2.1 Emissions Test Log

ERG performed extractive FTIR measurements for HCl and other HAPs. Table 2-1 presents the emissions test log which shows the test date, location, run number, test type and run times for each method.

Table 2-1. Emissions Test Log

Date	Location	Run Number	Test Type	Run Time
6/25/98	Baghouse (inlet/outlet)	Spike 1	FTIR HCl Spike (inlet/outlet)	09:53 - 11:53
6/25/98	Baghouse (inlet/outlet)	Run 1	FTIR (Unconditioned) FTIR (Conditioned)	15:18 - 18:54 12:25 - 13:45
6/25/98	Baghouse (inlet/outlet)	Spike 2	FTIR HCl Spike (inlet/outlet)	19:32 - 20:19

2.2 FTIR Results

2.2.1 Overview

FTIR data for HCl and other species were collected at the inlet and outlet of the baghouse. FTIR data collection of unconditioned samples was synchronized with EPA Method 23 manual dioxin/furan testing and EPA Method 322 GFC-IR HCl measurements. Conditioned samples were measured by FTIR for other HAP species.

FTIR data were collected by alternating sample analysis between inlet and outlet every 24 minutes. Inlet and outlet samples were drawn on a continuous basis; only the FTIR sample analysis was alternated between inlet and outlet. The first five data points from each 24 minute inlet/outlet measurement period were discarded to eliminate data for samples containing both inlet and outlet sample gas. Five data points correspond to the measured response time of the complete FTIR sampling and analysis system (details on measurement of system response time are given below). The measurement run contained a total of 76 and 95 1-minute average data points for both inlet and outlet measurements, after discarding the first five data points per set. A 1 minute average data point is generated by analysis of a composite spectrum consisting of an average of 43 FTIR spectra collected over the 1 minute time period.

Section 2.1 gives the schedule of the tests performed at the Chemical Lime Company in Marble Falls, Texas. Both unconditioned samples and conditioned samples were analyzed. Conditioned samples were generated by passing the raw sample gas through a sample conditioning system (See Section 3.1.1 for details). Conditioned samples extracted from the baghouse were measured prior to unconditioned sample extraction for one hour. Five minute average data points were generated by analysis of the composite spectrum consisting of an average of 215 FTIR spectra collected over the 5 minute time period. These results are reported in Section 2.2.2.2.

The baghouse removal efficiency for HCl was measured from the inlet/outlet data from each location and is reported in Section 2.2.2.1.

No attempt was made at correcting measurement data to a standard level of oxygen (e.g., 15%). Oxygen data were not collected by ERG.

2.2.2 FTIR Emission Results

This section contains the FTIR HCl test results for the baghouse inlet and outlet.

2.2.2.1 FTIR HCI Test Results

The estimated FTIR HCl detection limit for this study was in the range of 0.18 to 0.19 ppmv. Half of the FTIR instrument analysis time was split equally between inlet and outlet. Results given below are organized by location. HCl removal efficiency was also calculated for each run. Appendix C contains the raw 1-minute FTIR concentration data for all monitored species. All HCl emission tests were collected during the unconditioned runs.

Baghouse Outlet/Inlet HCl Results—Table 2-2 gives a summary of the baghouse outlet/inlet FTIR HCl results. The measured HCl removal efficiency due to the baghouse was 39.98 percent. Figures 2-1 and 2-2 show a real-time graph for the inlet and outlet runs, respectively. Due to the splitting of FTIR analysis time between inlet and outlet, the time axis in the graphs is not continuous.

2.2.2.2 Other Species Detected by FTIR

Other species were detected during the unconditioned FTIR test runs. The compounds were collected concurrently during the collection of the HCl test results. Results given below are organized by location. No additional HAP species were detected during the conditioned run. Appendix C contains a listing of 1-minute average values for all monitored analytes.

Table 2-2. Baghouse FTIR HCI Results, ppmv

	Run 1			
Date	6/25/98			
Time	15:18 - 18:54			
Location	Inlet Outlet			
Average	38.72	23.24		
SD	13.13 8.46			
Maximum	62.53	. 51.19		
Minimum	16.79 13.			
NDP	76 95			
RE	39	.98		

SD - Standard Deviation

NDP - Number of data points measured

RE- Removal Efficiency in percent: 100 X (Avg. inlet- Avg. outlet)/Avg. inlet

NOTE: Raw data are presented in Appendix C.

Baghouse Outlet/Inlet for Other Species Results—Table 2-3 and 2-4 respectively gives the summary of the baghouse for the inlet and outlet FTIR results for other species found during the standard Draft Method 320 extractive sampling and analysis.

HCI Inlet Run - Chemical Lime Company

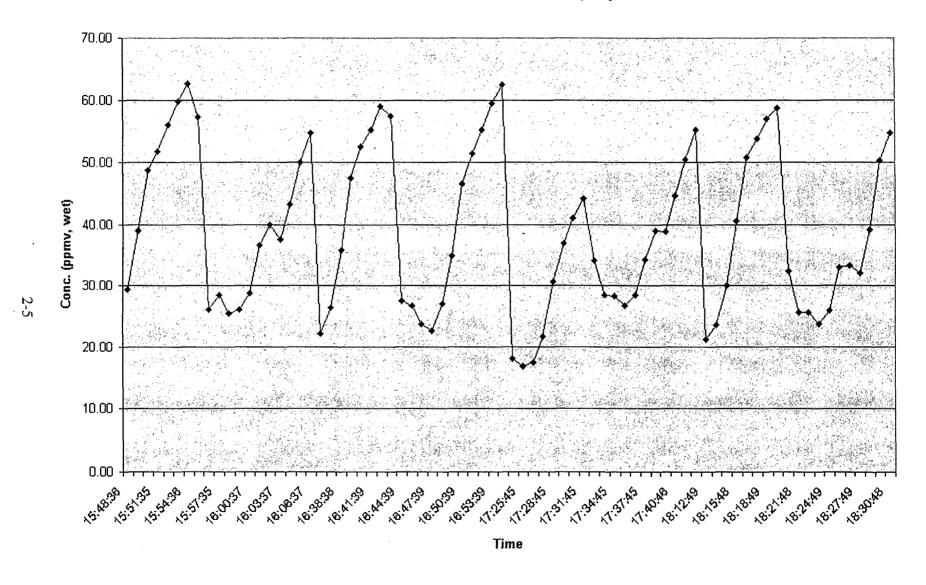


Figure 2-1. HCI Inlet Run - Chemical Lime Company

HCI Outlet Run - Chemical Lime Company

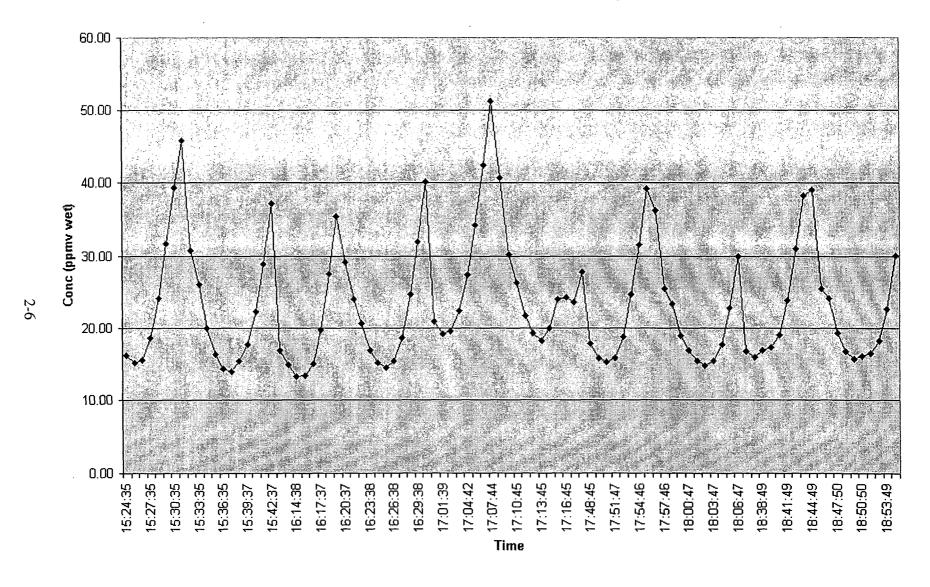


Figure 2-2. HCl Outlet Run - Chemical Lime Company

Table 2-3. Other Species Detected by FTIR - Baghouse Inlet

All values are ppmv, except CO_2 and H_2O in percent

Parameter	CO ₂	СО	NO	CH ₄	H ₂ O
U/C	U	U	U	U	U
Average	17.8	15.1	26.4	24.7	16.2
Std. Dev.	1.75	4.55	3.82	52.9	2.71
Max.	20.1	37.3	31.1	237.3	18.1
Min.	9.96	11.5	10.3	< 3.5	5.63
NDP	76	76	76	76	76
EDL	0.035	0.28	6.5	3.5	0.072

U/C - Unconditioned (U) or Conditioned (C) Sample

NDP - Number of data points.

EDL - Estimated detection limit for spectral region used for analysis

Std. Dev. = Standard Deviation

Max. = Maximum

Min. = Minimum

Table 2-4. Other Species Detected by FTIR - Baghouse Outlet

All values are ppmv, except CO₂ and H₂O in percent

Parameter	CO ₂	СО	NO	CH ₄	H ₂ O
U/C	U	U	U	U	U
Average	17.5	15.7	25.7	26.6	15.9
Std. Dev.	1.34	4.89	2.76	57.6	2.49
Max.	18.4	39.7	28.6	256	17.6
Min.	10.9	12.2	12.8	< 3.9	6.81
NDP	95	95	95	95	95
EDL	0.038	0.30	7.0	3.9	0.081

U/C - Unconditioned (U) or Conditioned (C) Sample

NDP - Number of data points

EDL - Estimated detection limit for spectral region used for analysis

Std. Dev. = Standard Deviation

Max. = Maximum

Min. = Minimum

3.0 SAMPLING AND ANALYTICAL PROCEDURE

The sampling and analytical procedure used by ERG for the lime plant test program is extractive FTIR spectroscopy, conducted in accordance with Draft EPA Method 320. In this section, description of the FTIR method used is provided.

3.1 Determination of Gaseous Organic HAPs, HCl, and Criteria Pollutants by Fourier Transform Infrared Spectroscopy (FTIR)

The extractive FTIR measurement method is based on continuous extraction of sample gas from the stack, transporting the sample to the FTIR spectrometer and performing real-time spectral measurement of the sample gas. The sample gas spectra are analyzed in real time for target analytes, archived and possibly re-analyzed at a later date for other target analytes. This section provides details on the FTIR sampling and measurement system.

3.1.1 FTIR Sampling Equipment

The FTIR measurement system meets the sampling and analysis requirements set forth in EPA Draft Method 320, "Measurement of Vapor Phase Organic and Inorganic Emissions By Extractive Fourier Transform Infrared Spectroscopy". This system has been used with complete success with many source categories, and can also be adapted to switch quickly between two sources (i.e., inlet and outlet) with a single FTIR spectrometer.

The sampling and measurement system consists of the following components:

- Heated probe;
- Heated filter:
- Heat-traced Teflon® sample line;
- Teflon[®] diaphragm, heated-head sample pump;
- FTIR spectrometer;

- FTIR sample conditioning system; and
- QA/QC apparatus.

Figure 3-1 illustrates the extractive unconditioned FTIR sampling and measurement system. In operation at a stationary source, the sample is continuously extracted from the stack through the heated probe. Sample gas is then sent into a heated filter assembly which will remove any particulate matter from the sample stream to protect the remainder of the sampling and analysis system. The probe liner and filter body are made of glass, and the filter element is polytetrafluoroethylene (PTFE or Teflon®). In addition to providing an inert surface, the glass filter holder allows the operator to observe the filter loading during sampling operations. The probe and filter are contained in a heated box which is mounted on the stack and maintained at a temperature of 177° C (350° F). A second probe/filter, heat-traced sample line, and heated head pump used are not shown in Figure 3-1.

After passing through the filter assembly, the sample gas is transported to the FTIR spectrometer by a primary heat-traced PTFE sample line maintained at approximately 177° C (350° F) driven by a heated- head PTFE diaphragm sample pump maintained at approximately 204° C (400° F). The sampling flow rate through the probe, filter, and sampling line is a nominal 20 standard LPM. Sample gas then enters an atmospheric pressure heated PTFE distribution manifold where it is sent to the FTIR spectrometer via a slipstream flowing at 9 LPM. Other slipstreams can be sent to other instruments, if necessary. Excess sample gas not used by instruments is vented to atmosphere.

FTIR spectrometer sample gas is taken from the distribution manifold by a secondary heated-head PTFE diaphragm sample pump maintained at approximately 204° C (400° F) and directed into the FTIR sample cell maintained at 185° C (365° F) for real-time analysis. The cell is made of nickel-plated aluminum, with gold-plated glass substrate mirrors and potassium chloride windows. Exhaust gas from the cell is vented to the atmosphere.

Figure 3-1. FTIR Sampling and Measurement System

Sample conditioning (when required) is achieved by passing raw sample gas through a PermaPure® dryer and a series of impingers filled with sodium (or lithium) hydroxide pellets. The PermaPure® drier selectively removes water vapor and the sodium hydroxide pellets remove CO₂ and other acid gases. The sample conditioning apparatus is switched into the FTIR sample path by a valving system. Lower detection limits for some compounds can be achieved with a conditioned sample.

3.1.2 Preparation for Sampling

Before commencement of daily sampling operations, the following tasks were carried out:

- System leak check;
- Measurement of FTIR background spectrum;
- Instrumental OC; and
- Sampling and measurement system QC spike run.

Detailed descriptions of these tasks are described in the paragraphs below.

The heated sampling lines, probes, and a heated filter were positioned at the inlet and outlet locations. All heated components were brought to operating temperature, and a leak check of both inlet and outlet sampling systems were performed. The leak check was performed by plugging the end of the probe and watching the main sample rotameter to observe the reading. Positive leak check was confirmed when the rotameter reading was zero.

A background spectrum was measured using zero nitrogen through the cell. Next the QC gases were measured. They agreed to within $\pm 6\%$ ($\pm 10\%$ for HCl) of target value. The QC gases used for this program include:

- Halocarbon 22, used to calibrate the pathlength. Halocarbon 22 is used for its highly linear response due to the lack of sharp spectral features, and is an extremely stable compound.
- Carbon monoxide (CO) used for frequency calibration. Carbon monoxide is
 directly injected into the sample cell to measure photometric accuracy, validity of
 the non-linear correction algorithm and serve as a frequency (i.e., wavelength)
 calibration. Acceptable limits for CO standard analysis are ±6 percent of certified
 concentration;
- Methane/nitric oxide/carbon dioxide mixture, used for overall system performance check (calibration transfer standard) (acceptance limits are ±6% of the certified concentration); and
- Hydrogen chloride standard, analyzed to verify the instrumental response of HCl, a key target analyte (acceptance limits are $\pm 10\%$ of certified concentration).

The sampling and measurement system spike test was done to perform validation and directly challenge the complete system and provide information on system accuracy and bias. This test is conducted to satisfy the requirements set in EPA Draft Method 320 entitled "Measurement of Vapor Phase Organic and Inorganic Emissions By Extractive Fourier Transform Infrared Spectroscopy". Section B.1.C of Method 320 gives a description of the dynamic spiking apparatus.

The FTIR spiking procedure used the following:

- Measured native stack gas until system equilibrates took 2 measurements (i.e., 2-1 minute samples);
- Started spike gas flow into sample stream, upstream of the heated filter;
- Let system equilibrate;
- Measured spiked sample stream for 2 minutes (i.e., 2-1 minute samples);
- Turned off spike gas flow;
- Let system equilibrate with native stack gas; and

Repeated cycle, two more times.

The above procedure produced 6 spiked/unspiked sample pairs. Spike recovery for 6 spiked/unspiked sample pairs were computed from the procedure given in Section 8.6.2 of EPA Draft Method 320. The recovery was between 70-130% and allowed the system to be considered acceptable for testing.

3.1.3 Sampling and Analysis

FTIR unconditioned sampling was performed simultaneously with the manual testing. The start and stop times of the manual methods were coordinated with the FTIR operator, so that FTIR data files can be coordinated with manual method start and stop times. FTIR inlet/outlet sampling was accomplished using two heated transfer lines, and a valving system to switch from inlet to outlet and vice versa.

Table 3-1 gives typical FTIR operating conditions. These parameters provide detection limits of 0.1-1 ppm for typical FTIR analytes, while providing adequate dynamic range (nominally 1-1000 ppm). Some of these parameters are sample matrix dependent.

Sample flow rate was determined by the data averaging interval and FTIR spectrometer sample cell volume. A minimum of 3 sample cell volumes of gas must flow through the system to provide a representative sample during a single integration period. Typically, a 1 minute averaging period with a 3 liter volume sample cell gives a minimum flow rate of 9 LPM. Typically a flow rate of 20 standard LPM is used to accommodate the FTIR and other instrumentation on-site, and to minimize sample residence time in the sampling system.

Table 3-1. Typical FTIR Operating Parameters

Parameter	Value
Spectral Range (cm ⁻¹)	400 - 4000
Spectral Resolution (cm ⁻¹)	0.5
Optical Cell Pathlength (m)	3.4
Optical Cell Temperature (° C)	185
Sample Flow Rate (liters/minute)	9 (3.0 optical cell volumes/minute)
Integration Time (minutes)	1 (Average of 43 spectra)

The temperature of all sampling system components were at a minimum of 177°C (350 °F) to prevent condensation of water vapor or other analytes in the sampling system. Actual sampling system operating temperatures were determined before the start of testing. The FTIR sample cell temperature was maintained at 365° F (185° C) to ensure that condensation of high-boiling point analytes on the cell optics was minimized.

FTIR sample cell pressure was monitored in real-time in order to calculate analyte concentration in parts-per-million. The cell was normally operated near atmospheric pressure with the cell pressure continuously monitored.

Sampling probe location was determined by the requirements set in EPA Method 1 in terms of duct diameters upstream and downstream of disturbances. Concurrent EPA Method 2 velocity measurements were not carried out at the same process stream location as the FTIR sampling point to provide mass emission rate determination. The stack gas velocity and flow rate were determined by the applicable manual test methods performed by PES. Velocity information can be found from the report prepared by PES.

Sampling and analysis procedures are straightforward for a single-source measurement.

Once QA/QC procedures were completed at the beginning of the test day, the sample was allowed to flow continuously through the FTIR spectrometer cell and the software was instructed

to start spectral data collection. The spectrometer collected one interferogram per second and averaged a number of interferograms to form a time-integrated interferogram. The typical averaging times range was approximately 1 minute. The interferogram was converted into a spectrum and analyzed for the target analytes. After spectral analysis, the spectrum was stored on the computer and later permanently archived. Spectral data collection was stopped after a predetermined time, corresponding to a "run". Typical runs were approximately 3 hours long, giving a minimum of 180 one-minute averaged points for each target analyte. The figure of 180 points were reduced by 30 points due to elimination of five data points per switch between inlet/outlet samples and vice versa. At the end of the test day, the end-of-day QA/QC procedures were conducted.

Before any testing was started at a given site, an initial "snapshot" of the stack gas was taken with the FTIR measurement and analysis system to determine the true sample matrix. Because sample conditioning was required for certain analytes, the FTIR spectrometer analyzed these compounds after the unconditioned analysis. The order used during this program is shown in the table below.

Sampling Conditions	Sampling Time	Inlet	Outlet
Unconditioned	Synchronized with dioxin sampling	5 minute cell purge and 19 minute sample collection	5 minute cell purge 19 minute sample collection
Conditioned	I hour (after completion of dioxin run)	2 minute cell purge and 28 minute sample collection	2 minute cell purge and 28 minute sample collection

The sample being delivered to the FTIR cell alternated between the inlet and the outlet. The switching valve, located just upstream of the common manifold, was manually activated periodically to provide alternating inlet and outlet sample collections during each three-hour period (the estimated dioxin run duration). This procedure resulted in a set of data points

collected for the inlet and outlet, respectively. Five data points per set are discarded to eliminate analysis results with combined inlet and outlet samples.

FTIR method performance was gauged from the results of the QA/QC procedures given in Section B5 of Draft EPA Method 320. Acceptable spiking tests met acceptance for accuracy of within \pm 30 percent. The acceptable instrument diagnostic and system response checked accuracy to be within \pm 6 percent of target for all gas standards, and \pm 10% for the HCl standards. Acceptable system response check precision was 6 percent RSD.

Quantitative analysis was performed by a mathematical method called multi-variate least squares (commonly known as Classical Least Squares or CLS). CLS constructs an optimized linear combination (or 'fit') of the reference spectra to duplicate the sample spectrum, utilizing the Beer-Lambert Law. The Beer-Lambert Law states that the absorbance of a particular spectral feature due to a single analyte is proportional to its concentration. This relationship is the basis of FTIR quantitative analysis. The coefficients of each compound in the linear fit yield the concentration of that compound. If it is found that the quantitative analysis of a given compound responds non-linearly to concentration, a calibration curve is developed by measuring a series of reference spectra with differing optical depths (concentration times pathlength) and using them in the linear fit. Low molecular weight species such as water vapor and carbon monoxide require non-linear correction, possibly even at levels as low as 100 ppm-meters (concentration times pathlength). Analytes greater than 50-60 amu molecular weight usually do not require non-linear corrections. An experienced spectroscopist can determine whether non-linear corrections are necessary for an analyte in a given source testing scenario.

The ERG validated spectral database includes the compounds shown in Table 3-2. These spectra were validated in the laboratory at a cell temperature of 185° C against certified gaseous standards. Any compounds identified in the stack gas and not included in the ERG database can be quantified if necessary after subsequent laboratory reference spectrum generation.

Table 3-2. Compounds for Which Reference FTIR Spectra Are Available in the ERG Spectral Library^a

1-butene	chlorobenzene	<i>n</i> -butanol	
1,3-butadiene	cis-2-butene	<i>n</i> -butane	
2-methylpropane	cyclohexane	n-pentane	
2-propanol	cyclopentane	nitric oxide	
2-methoxyethanol	cyclopropane	nitrogen dioxide	
2-methyl-2-propanol	ethane	nitrous oxide	
2-methylbutane	ethylbenzene	o-cresol	
4-vinylcyclohexane	ethylene	o-xylene	
acetaldehyde	formaldehyde	p-cresol	
acetic acid	hydrogen fluoride	<i>p</i> -xylene	
acetone	hydrogen chloride	phenol	
acetylene	isobutylene	propane	
acrolein	<i>m</i> -xylene	propylene	
ammonia	m-cresol	styrene	
benzene	methane	sulfur dioxide	
carbon monoxide	methanol	toluene	
carbon dioxide	methyl ethyl ketone	trans-2-butene	
carbonyl sulfide	methylene chloride	water vapor	

^a Spectra were collected at a cell temperature of 185° C.

3.1.4 FTIR Method Data Review Procedures

The following procedure was conducted to review and validate the FTIR data.

A. Post-test Data Review procedure (on-site)

- 1. Examine the concentration vs. time series plot for each compound of interest, and identify regions with the following characteristics:
 - sudden change in concentration;
 - unrealistic concentration values;
 - significant changes in 95 percent confidence intervals reported by software; and
 - sudden increase of noise in data.
- 2. Select representative spectra from the time periods indicated from Step 1.
- 3. Subtract from each representative spectrum chosen in Step 2 a spectrum which was taken immediately prior in time to the indicated time region.
- 4. Manually quantitate (including any non-linear corrections) for the species in question and compare the result to the difference in software-computed concentrations for respective spectra.
- 5. If concentration values in Step 4 do not agree to within 5 percent, determine whether the difference is due to a recoverable or non-recoverable error.
- 6 (i). If the error is non-recoverable, the spectra in the indicated time region are declared invalid.
- 7 (ii). If the error is recoverable, and time permits, determine possible source(s) of error and attempt to correct. If time is critical, proceed with measurement. If correction is achieved, conduct QA/QC checks before continuing.
- 8. Determine the peak-to-peak scatter or the root mean square (RMS) noise-equivalent-absorbance (NEA) for the representative spectra.
- 9. If the NEA exceeds the limits required for acceptable detection limits, the spectra in the time region are declared invalid (due to non-recoverable error).

10. Data found invalid are subject to re-measurement.

B. Final Data Review (off-site)

The procedures for final data review include those given above; however, if a non-recoverable error was found during this phase, the data are considered invalid. In addition, the following procedures are carried out by the spectroscopist to perform a final data validation:

- 1. If any recoverable data errors are detected from the procedure, determine the cause and perform any necessary corrections.
- 2. For analytes which were not detected or detected at low levels:
 - a) estimate detection limits from validated data;
 - b) check for measurement bias.
- 3. Verify spreadsheet calculations by independent calculation (results in Appendix A).

3.1.5 FTIR QA/QC Procedures

The FTIR QA/QC apparatus will be used to perform two functions:

- Dynamic analyte spiking; and
- Instrumental performance checks.

Dynamic analyte spiking was used for quality control/quality assurance of the complete sampling and analysis system. Dynamic spiking is continuous spiking of the sample gas to provide information on system response, sample matrix effects, and potential sampling system biases. Spiking is accomplished by either:

- Direct introduction of a certified gas standard; or
- Volatilization of a spiking solution.

Certified gas standards are preferred due to simplicity of use, but many target analytes cannot be obtained as certified gas standards, and must be spiked using standards generated by volatilized solutions.

Gaseous spiking is carried out by metering the spike gas into the sample stream at a known rate. Spike levels are calculated from mass balance principles. When certified gas standards are used, a dilution tracer, such as sulfur hexafluoride, is used to directly measure the fraction of spike gas spiked into the sample. This technique can be used instead of mass balance calculations.

FTIR method performance is gauged from the results of the QA/QC. Acceptable spiking tests will meet Method 320 criteria (i.e., accuracy of within ± 30 percent) or a statistical equivalent when less than 12 spiked/unspiked pairs are collected. Draft EPA Method 320 instructs the user to determine the percent spike recovery of 3 pairs of spiked/unspiked samples. The Draft EPA Method 320 acceptance criterion is 70 to 130 percent recovery for the three pairs of samples. The acceptable instrument diagnostic and system response check accuracy were within ± 6 percent of target (±10 percent for HCl standards). Acceptable system response check precision was 6 percent RSD.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Specific Quality Assurance/Quality Control (QA/QC) procedures were strictly followed during this test program to ensure the production of useful and valid data throughout the course of the project. A detailed presentation of QC procedures for all sampling and analysis activities can be found in the Site Specific Test Plan and Quality Assurance Project Plan for this project. This section reports all QC results so that the data quality can be ascertained.

In summary, a high degree of data quality was maintained throughout the project. All sampling system leak checks met the QC criteria as specified in Method 320. Acceptable spike recoveries and close agreement between duplicate analyses were shown for the sample analyses. The data completeness was 100 percent, based on changes authorized by the Work Assignment Manager.

4.1 FTIR Analytical Quality Control

Dynamic analyte spiking was used for quality control/quality assurance of the complete sampling and analysis system. Dynamic spiking is continuous spiking of the sample gas to provide information on system response, sample matrix effects, and potential sampling system biases. Spiking was accomplished by direct introduction of a certified gas standard.

Gaseous spiking was carried out by metering the spike gas into the sample stream at a known rate. A sulfur hexafluoride dilution tracer was used to directly measure the fraction of spike gas spiked into the sample. EPA Method 320 limits the dilution of the sample gas to 10 percent.

Before any testing was started at a given site, an initial "snapshot" of the stack gas is taken with the FTIR measurement and analysis system to determine the true sample matrix. If any target analytes are present at significantly higher levels than expected, adjustments were

made to the cell pathlength and/or the spectral analysis regions used for quantitative analysis.

These adjustments minimized interferences due to unexpectedly high levels of detected analytes.

FTIR method performance is gauged from the results of the QA/QC. All spiking tests met Method 320 criteria. The acceptable instrument diagnostic and system response check accuracy should be within \pm 6 percent of target for all gas standards except HCl. The accuracy for the HCl standard should be within \pm 10 percent.

Analytical QC checks for the FTIR system consisted of the following:

- Dynamic spiking of HCl;
- Direct measurement of a HCl gas standard;
- Direct measurement of a CO gas standard; and
- Direct measurement of a CH₄, NO, and CO₂ standard.

Dynamic spiking runs were conducted twice daily: before and after testing. Six spiked/unspiked data points were collected. Statistical calculations consistent with EPA Method 301 were performed on the data. Recovery of 70-130 percent was the acceptance criteria. Tables 4-1 and 4-2 summarize the dynamic spiking results. All dynamic spiking tests met the above acceptance criteria. In all runs, sample gas was diluted 10 percent or less.

Direct instrumental measurement of HCl, CO, H22, and a CH_4 , NO_2 and CO_2 mixture was conducted before and after daily testing activities. Acceptance criteria are normally ± 6 percent of target, using EPA protocol gases. However, since the HCl standard was obtained at a ± 5 percent analytical tolerance, the acceptance criteria was set at ± 10 percent. FTIR NO_x is measured as $NO + NO_2$. Examination of Table 4-3 shows that all QC checks met the above criteria.

Table 4-1. HCI QC Pre-test Spike Results - Chemical Lime Company

	Outlet									
Spike Run Number	Lowest Unspiked Value (ppmv)	Spiked (ppmv)	Corrected Difference (ppmv)	Spike Level (ppmv)	% Recovery	SF6 Conc. (ppmv)	Dilution Ratio			
1	10.16	41.26	32.00	22.41		0.450	0.089			
2	16.26	49.40	34.55	21.91		0.440	0.087			
3	10.44	33.68	24.08	20.42		0.410	0.081			
4	14.28	41.83	28.70	20.42		0.410	0.081			
5	7.68	25.21	18.10	18.93		0.380	0.075			
6	9.30	29.35	20.75	18.93		0.380	0.075			
Average	11.35	36.79	26.36	20.50	128.55	0.412	0.081			
			Inlet							
Spike Run Number	Lowest Unspiked Value (ppmv)	Spiked (ppmv)	Corrected Difference (ppmv)	Spike Level (ppmv)	% Recovery	SF6 Conc. (ppmv)	Dilution Ratio			
1	44.92	67.72	26.69	21.91		0.440	0.087			
2	48.20	68.28	24.25	21.91		0.440	0.087			
3	47.41	60.27	16.78	20.92		0.420	0.083			
4	50.27	69.44	23.23	20.42		0.410	0.081			
5	40.32	59.97	22.90	20.42		0.410	0.081			
6	46.91	58.64	15.61	20.92		0.420	0.083			
Average	46.34	64.05	21.58	21.08	102.34	0.423	0.083			

NOTE: The spike runs were conducted before and after the test runs, therefore the minimum and maximum values listed here may be different than those listed in the test runs, Section 2. Sample gas dilution was held to 10 percent or less in all runs. Percent recovery is defined in Draft Method 320.

(Stock spike gas values for HCl and SF₆ values are 253 ppmv and 5.08 ppmv, respectively).

Table 4-2. HCI QC Post-test Spike Results - Chemical Lime Company

	Outlet									
Spike Run Number	Lowest Unspiked Value (ppmv)	Spiked (ppmv)	Corrected Difference (ppmv)	Spike Level (ppmv)	% Recovery	SF6 Conc. (ppmv)	Dilution Ratio			
1	18.01	39.43	22.12	23.91		0.480	0.094			
2	· 16.48	40.37	25.45	23.91		0.480	0.094			
3	16.42	43.68	28.81	23.91		0.480	0.094			
4	18.58	49.17	32.35	23.91		0.480	0.094			
5	22.71	56.48	35.92	23.91		0.480	0.094			
6	29.98	63.10	35.95	23.91		0.480	0.094			
Average	20.36	48.54	30.10	23.91	125.91	0.482	0.094			
			Inlet							
Spike Run Number	Lowest Unspiked Value (ppmv)	Spiked (ppmv)	Corrected Difference (ppmv)	Spike Level (ppmv)	% Recovery	SF6 Conc. (ppmv)	Dilution Ratio			
1	41.09	51.31	13.70	21.42		0.430	0.085			
2	49.65	56.36	10.91	21.42		0.430	0.085			
3	53.18	66.38	17.70	21.42		0.430	0.085			
4	56.64	74.24	22.39	21.42		0.430	0.085			
5	60.27	76.06	20.89	21.42		0.430	0.085			
6	63.10	78.46	20.70	21.42		0.430	0.085			
Average	53.99	67.14	17.72	21.42	82.73	0.430	0.085			

NOTE: The spike runs were conducted before and after the test runs, therefore the minimum and maximum values listed here may be different than those listed in the test runs, Section 2. Sample gas dilution was held to 10 percent or less in all runs. Percent recovery is defined in Draft Method 320.

(Stock spike gas values for HCl and SF₆ values are 253 ppmv and 5.08 ppmv, respectively).

Table 4-3. Gas Standard Analysis Results

Date	Time	Compound	True (ppm)*	Result (ppm)*	% Recovery	Comments
6/25/98	08:31 AM	HCl CO CH₄ NO CO₂ H22	253 102.3 491 503 4.99 %	249.8 102.1 487.9 502.7 4.95 % 3.35 m	98.7 99.8 99.4 99.9 99.2	
6/25/98	08:40 PM	HCI CO CH₄ NO CO₂ H22	253 102.3 491 503 4.99 %	249.9 101.7 489.6 500.6 4.96 % 3.36 m	98.8 99.4 99.7 99.5 99.4	

HCl Gas Standard Accuracy: ±5 percent; Acceptance Criteria: ±10 percent of target.

CO Gas Standard Accuracy: ±1 percent; Acceptance Criteria: ±6 percent of target.

CH₄, NO₂, and CO₂ Gas Standard Accuracy; ±1 percent; Acceptance Criteria: ±6 percent of target.

^{*} All compounds are recorded in ppm except for CO₂ in percent (%), and H22 in meters (m).

The Halocarbon 22 (H22) is used to calibrate the pathlength.

APPENDIX A

FTIR DATA SPREADSHEET CALCULATION QA/QC SHEETS

FTIR QA/QC REVIEW Calculation and Methodology QA/QC Checklist

- For each facility tested, the reviewer will have:
 - 1. Excel QA/QC workbook
 - 2. Inlet and Outlet QA/QC information

Facility Name: Chemline Lime Klw						TWE-25-K44 TIME: 12:25:44
Source Location (INLET or OUTLET)						
Run Description Run 01 Conditioned TNUET Reviewer: MUHAEL BUANT						
Reviewer: MICHAEL BRYANT						Date: Oli- 143
Checklist	Yes	No :	N/A	Not det.*	Resolution	
A. QA/QC entries match references values Check the following by comparing the printout	of the O	A/QC n	ın to the	original	run information:	
Pollutants matches pollutants in both the original and QA/QC data	V					
2. Times for Inlet/Outlet samples match.						
3. Number of data points match. 7/4						
4. Column statistics match (i.e., Average, Standard Deviation, Maximum, Minimum)	V					
 Verify that the QA/QC value is zero. This indicated that both the original and the QA/QC values are identical. 	V				·	
B: Check that calculations are correct						
No mathematical errors	V					The second secon
2. No errors in the data macro	V					
E. Comments	1		<u> </u>	I		
All det & identical	\ \ \	A.1.(6.0.2.2)	**************************************		MusaA	< D-2-18
2.					17)	> / / / · ·

^{*} Not able to determine

FTIR QA/QC REVIEW Calculation and Methodology QA/QC Checklist

- For each facility tested, the reviewer will have:
 - 1. Excel QA/QC workbook
 - 2. Inlet and Outlet QA/QC information

Facility Name: Chemline Line Kiln					DATE:	
CHAIME LINE KILL					JUNE-25- 408	
Source Location (INLET or OUTLE)	r)					TIME:
OUTLET						12:25:49
Run Description (NO 0)						
Cinditioned						•
Reviewer:						Date:
Michel DOANI						te-2-53
			. —			
Checklist	Yes	No	N/A	Not	Resolution	
The state of the s				det.*		
A. QA/QC entries match references values Check the following by comparing the printout	aftha O	koc-		o-amal		
Pollutants matches pollutants in both the	Отшес	AVQC II	m to me	Original	tunimormation.	
original and QA/QC data		1				
2. Times for Inlet/Outlet samples match.						
3. Number of data points match. %	-/	 				
3. Number of data points match.						
4. Column statistics match (i.e., Average,	1					
Standard Deviation, Maximum, Minimum)		/				
5. Verify that the QA/QC value is zero. This indicated that both the original and the	V					
QA/QC values are identical.					·	
B. Check that calculations are correct		for the		Senta:		
i. No mathematical errors		ye.		i i	8,	
1. 140 triathematical errors						
2. No errors in the data macro	1					
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E. Comments					\sim	
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All day is identical	<u> </u>			<u> </u>	Think!	12-2-70
					7	-

^{*} Not able to determine

FTIR QA/QC REVIEW Calculation and Methodology QA/QC Checklist

- For each facility tested, the reviewer will have:
 - 1. Excel QA/QC workbook
 - 2. Inlet and Outlet QA/QC information

Facility Name: -	101					DATE:
racinty Name: Chemine Line	Kilv	`				JUNE 25-98
Source Location (INLET or OUTLE)						TIME:
TNIET						15:18:38 (START)
Run Description Run 2 Outler &	'- · ·					10 00
KUN 2 001 (FEE)	Inlet					
unconditored						
Designation of the second						Datas
Reviewer Michael Bryant						Date: Dec-2-48
Checklist	Yes	No	N/A	E AND FOUND	Resolution	
	能認識			det.*		
A.QA/QC entries match references values	福德		11.25.75		美国的	
Check the following by comparing the printout	of the Q	A/QC n	n to the	original:	nin information:	
1. Pollutants matches pollutants in both the	1/]				
original and QA/QC data	10/	†——				
2. Times for Inlet/Outlet samples match.	V	-				
3. Number of data points match. 76/76						
4. Column statistics match (i.e., Average,	1.7					
Standard Deviation, Maximum, Minimum)	U	<u>/</u>	<u></u>			
5. Verify that the QA/QC value is zero. This	1./	1				
indicated that both the original and the QA/QC values are identical.	V	ļ				
B Check that calculations are correct.	Participation of the Control of the			i de la company		Walter Commence
		e ne is				
No mathematical errors						and a second and a second and a second as a second asset as a second asset as a second as a second as a second
	V			l _		
2. No errors in the data macro	1./					
	10					
E. Comments						
		1000	(5.84 - 6.8 <u>9</u>		~ 2	
Fres Mada GA/QC OK	V				Musch	12-2-58
2.					2/1	
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				1	ر	
	<u> </u>					

^{*} Not able to determine

FTIR QA/QC REVIEW Calculation and Methodology QA/QC Checklist

- For each facility tested, the reviewer will have:
 - 1. Excel QA/QC workbook
 - 2. Inlet and Outlet QA/QC information

Facility Name: Chemline Line Kiln					JUNE -25.1998	
Source Leasting (INLET or OUTLET)					TIME:	
Source Location (INLET or OUTLET)						
OUTLET						15:18:38 5TME
Run Description Run 2 Outlet/1 Unconditioned	nlet					
Manadhared						
Orco racino —						
D						TD-4
Reviewer: Michael Brugart						Date:
						1000
Checklist	: Yes	No	N/A	Not	Resolution	
				det.*		
A. QA/QC entries match references values	d5.6 2 6.0	/-	44044			C/400E4956467475
Check the following by comparing the printou	t of the Q	K QC _n	in to the	original	run information:	
1. Pollutants matches pollutants in both the	1.7	1				
original and QA/QC data	V					
2. Times for Inlet/Outlet samples match.						
3. Number of data points match.	95/51	/				
4. Column statistics match (i.e., Average,	1/1/					
Standard Deviation, Maximum, Minimum)			Ĺ			
5. Verify that the QA/QC value is zero. This	1	}	i			
indicated that both the original and the			}			
QA/QC values are identical. B. Check that calculations are correct.	V	Table Sales	+4110 Keledino	Capture/Article and a	Suidage Changar agradas	
26. Check that calculations are correct						
i. No mathematical errors						AND THE REAL PROPERTY AND THE PROPERTY OF THE
2. No errors in the data macro	V					
E. Comments		<u> </u>			<u> </u>	
THE REPORT OF THE PARTY OF THE		1750	200			
1. Files Match QA/QC OK					M.D.I.	12-2-58
2.					4	
	+			-		J
	1	1	Ì	1]	

^{*} Not able to determine

APPENDIX B GAS CYLINDER CERTIFICATION SHEETS



3434 Route 22 West • Branchburg, NJ 08876 USA Tel: (908) 252-9300 • (800) 932-0624 • Fax: (908) 252-0811

SHIPPED FROM: 80 INDUSTRIAL DRIVE ALPHA, NJ. 08865 TEL: (908) 454-7455

SHIPPED TO:

Eastern Research Group Inc.

900 Perimeter Park Morrisville, NC 27560

CERTIFICATE

OF

ANALYSIS

SGI ORDER #:

134942

ITEM#:

CERTIFICATION DATE: 8/10/98

P.O.#:

9101008011-R132

BLEND TYPE:

CERTIFIED

CYLINDER #: 1689487Y

CYLINDER PRES: 2000 psig

CYLINDER VALVE: CGA 330

ANALYTICAL ACCURACY: +/-5%

COMPONENT	REQUESTED GASCONC	ANALYSIS
Hydrogen Chloride Sulfur Hexafluoride	50.0 ppm 2.00 ppm	54.3 ppm 2.01 ppm
Nitrogen	Balance	Balance

Sulfur Hexafluoride is +/- 2%

ANALYST:	-21	
	Ted Neeme	

DATE: 8/10/98

Ted Neeme

277 Coit Street • Irvington, NJ 07111 USA Tel: (973) 372-2060 • (800) 929-2427 • Fax: (973) 372-8551

SHIPPED FROM: 80 IN	DUSTRIAL DRIVE ALP	HA, NJ. 08865 TEL: ((908) 454-7455	
SHIPPED TO:	Eastern Research Grou 900 Perimeter Park Morrisville , NC 27560			
		CERTIFICATE		
		OF		
		ANALYSIS		
SGI ORDER #:	126876			
ITEM#:	1		CYLINDER #:	1852209Y
CERTIFICATION DATE:	8/29/97		CYLINDER PRES:	2000 PSIG
BLEND TYPE:	CERTIFIED		P.O.#:	7904004005-R562
		REQUESTED GAS		ANALYSIS
COMPONENT		CONC		
Hydrogen Chloride	•	200 ppm	•	210 ppm
Sulfur Hexafluoride	•	20.0 ppm		20.2 ppm
Nitrogen		Balance		Balance
ANALYST:			DATE:	8/29/97

277 Coit Street • Irvington, NJ 07111 USA Tel: (973) 372-2060 • (800) 929-2427 • Fax: (973) 372-8551

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SHIPPED TO:

Eastern Research Group Inc.

900 Perimeter Park Morrisville, NC 27560

CERTIFICATE

OF

ANALYSIS

SGI ORDER #:

128118

ITEM#:

1

CERTIFICATION DATE: 10/16/97

BLEND TYPE:

CERTIFIED

CYLINDER #:

1757972Y

CYLINDER PRES: 2000 psig

P.O.#:

7904004005-R690

ANALYTICAL ACCURACY:

+/- 2%

COMPONENT Hydrogen Chloride** Sulfur Hexafluoride

REQUESTED GAS CONC 200 ppm 20.0 ppm

220 ppm 20.0 ppm

ANALYSIS

Nitrogen

Balance

Balance

** Analytical Accuracy of Hydrogen Chloride is +/- 5%

ANALYST:

Ted Neeme

DATE:

10/16/97



277 Coit Street • Irvington, NJ 07111 USA Tel: (973) 372-2060 • (800) 929-2427 • Fax: (973) 372-8551

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SHIPPED TO:

Eastern Research Group Inc.

900 Perimeter Park Morrisville, NC 27560

CERTIFICATE

OF

ANALYSIS

SGI ORDER #:

BLEND TYPE:

132874

ITEM#:

2

CERTIFICATION DATE: 5/11/98

CERTIFIED

CYLINDER #:

1370597Y

CYLINDER PRES: 2000 psig

P.O.#:

9101008004-R986

ANALYTICAL ACCURACY:

+/- 2%*

COMPONENT	REQUESTED GAS CONC	ANALYSIS
Hydrogen Chloride	250 ppm	253 ppm
Sulfur Hexafluoride	5.00 ppm	5.08 ppm
Nitrogen	Balance	Balance

DATE:

5/11/98

^{*} Analytical Accuracy of Hydrogen Chloride is +/- 5%

3434 Route 22 West • Branchburg, NJ 08876 USA Tel: (908) 252-9300 • (800) 932-0624 • Fax: (908) 252-0811

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Eastern Research Group Inc.

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CERTIFICATE

OF

ANALYSIS

SGI ORDER #:

134942

ITEM#:

CERTIFICATION DATE: 8/10/98

P.O.#:

9101008011-R132

BLEND TYPE:

CERTIFIED

CYLINDER #: 1015632Y

CYLINDER PRES: 2000 psig

CYLINDER VALVE: CGA 330

ANALYTICAL ACCURACY: +/-5%

COMPONENT	REQUESTED GAS CONC	ANALYSIS
Hydrogen Chloride Sulfur Hexafluoride	250 ppm 2.00 ppm	260 ppm 2.00 ppm
Nitrogen	Balance	Balance

Sulfur Hexafluoride is +/- 2%

ANALYST:	181
	Ted Neeme

DATE: 8/10/98 277 Coit Street • Irvington, NJ 07111 USA Tel: (973) 372-2060 • (800) 929-2427 • Fax: (973) 372-8551

SHIPPED FROM: 80 INDUSTRIAL DRIVE ALPHA, NJ. 08865 TEL: (908) 454-7455

SHIPPED TO:

Eastern Research Group Inc.

900 Perimeter Park Morrisville, NC 27560

CERTIFICATE

OF

ANALYSIS

SGI ORDER #:

132874

ITEM#:

1

CERTIFICATION DATE: 5/11/98

CYLINDER #:

1757934Y

CYLINDER PRES: 2000 psig

BLEND TYPE:

CERTIFIED

P.O.# :

9101008004-R986

ANALYTICAL ACCURACY:

+/- 2%*

COMPONENT	REQUESTED GAS CONC	ANALYSIS
Hydrogen Chloride	500 ppm	516 ppm
Sulfur Hexafluoride	5.00 ppm	5.09 ppm
Nitrogen	Balance	Balance

DATE:

5/11/98

^{*} Analytical Accuracy of Hydrogen Chloride is +/- 5%



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SHIPPED TO:

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CERTIFICATE

OF

ANALYSIS

SGI ORDER #:

134942

ITEM#:

3

8/10/98

CERTIFICATION DATE: 8

/10/98

P.O.#: BLEND TYPE: 9101008011-R132

CERTIFIED

CYLINDER #: 982153Y

CYLINDER PRES: 2000 psig CYLINDER VALVE: CGA 330

ANALYTICAL ACCURACY: + / - 5%

COMPONENT	REQUESTED GAS CONC	ANALYSIS
Hydrogen Chloride Sulfur Hexafluoride	1,000 ppm 2.00 ppm	1,030 ppm 2.02 ppm
Nitrogen	Balance	Balance

Sulfur Hexafluoride is +/- 2%

ANALYST:	13 H	DATE:	8/10/98
	Ted Neeme		



SPECTRA GASES

277 Coit St. • Irvington, NJ 07111 USA Tel.: (201) 372-2060 • (800) 932-0624 • Fax: (201) 372-8551 Shipped From: 80 Industrial Drive • Alpha, N.J. 08865



C	FR	TII	FIC	`Δ	TF	OF	ΔΙ	VΔ	I١	15	S
•				_	-	~	~,	1/7	_		

EPA PROTOCOL MIXTURE

PROCEDURE #: G1

CUSTOMER:

Eastern Research Group Inc.

CYLINDER #:

CC80890

SGI ORDER #:

126876

CYLINDER PRES: 2000 PSIG

CTLINDER PRE

350

ITEM#: P.O.#:

3

CERTIFICATION DATE: 8/26/97

EXPIRATION DATE:

: 8/26/9/ 8/26/2000

7904004005-R562

CERTIFICATION HISTORY

COMPONENT	DATE OF ASSAY	MEAN CONCENTRATION	CERTIFIED CONCENTRATION	ANALYTICAL ACCURACY
Carbon Monoxide	8/19/97	102.1 ppm	102.3 ppm	+/- 1%
···	8/26/97	102.6 ppm		

•			i	

BALANCE

Nitrogen

REFERENCE STANDARDS

COMPONENT	SRM/NTRM#	CYLINDER#	CONCENTRATION
Carbon Monoxide	SRM-1680b	CLM010013	490.4 ppm
	 		
	1 1		1

INSTRUMENTATION

COMPONENT	MAKE/MODEL	SERIAL#	DETECTOR	CALIBRATION DATE(S)
Carbon Monoxide	Horiba-VIA-510	570423011	NDIR	8/26/97

THIS STANDARD WAS CERTIFIED ACCORDING TO THE EPA PROTOCOL PROCEDURES. DO NOT USE THIS STANDARD IF THE CYLINDER PRESSURE IS LESS THAN 150 PSIG.

ANALYST:

DATE:

8/26/97

277 Coit Street • Irvington, NJ 07111 USA Tel: (973) 372-2060 • (800) 929-2427 • Fax: (973) 372-8551

SHIPPED FROM: 80 INDUSTRIAL DRIVE ALPHA, NJ. 08865 TEL: (908) 454-7455

SHIPPED TO:

Eastern Research Group Inc.

900 Perimeter Park Morrisville, NC 27560

CERTIFICATE

OF

ANALYSIS

SGI ORDER #:

128118

ITEM#:

2

CERTIFICATION DATE: 10/16/97

BLEND TYPE:

CERTIFIED

CYLINDER #:

CC82244

CYLINDER PRES: 2000 psig

P.O.#:

7904004005-R690

ANALYTICAL ACCURACY:

+/- 2%

COMPONENT

REQUESTED GAS

ANALYSIS

Chlorodifluoromethane

CONC 40.0 ppm

40.3 ppm

Nitrogen

Balance

Balance

ANALYST: Ted Neeme

DATE:

10/16/97



SPECTRA GASES

277 Coit St. • Irvington, NJ 07111 USA Tel.: (201) 372-2060 • (800) 932-0624 • Fax: (201) 372-8551 Shipped From: 80 Industrial Drive • Alpha, N.J. 08865



CERTIFICATE OF ANALYSIS

EPA PROTOCOL MIXTURE

PROCEDURE #: G1

CUSTOMER:

Eastern Research Group Inc.

CC79878

SGI ORDER #:

126876

CYLINDER #: CYLINDER PRES: 2000 PSIG

ITEM#:

CGA OUTLET:

660

P.O.#:

7904004005-R562

CERTIFICATION DATE: 8/27/97

EXPIRATION DATE: 8/19/99

CERTIFICATION HISTORY

COMPONENT	DATE OF ASSAY	MEAN CONCENTRATION	CERTIFIED CONCENTRATION	ANALYTICAL ACCURACY
Methane	8/21/97	491 ppm	491 ppm	+/- 1%
Nitric Oxide	8/20/97 8/27/97	502.1 ppm 504.6 ppm	503 ppm	+/- 1%
NOx		\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	503 ppm	Reference Value Only
Carbon Dioxide	8/19/97	4.99 %	4.99 %	+/- 1%

BALANCE

Nitrogen

REFERENCE STANDARDS

COMPONENT	SRM/NTRM#	CYLINDER#	CONCENTRATION
Methane	SRM-2751	CAL013479	98.6 ppm
Nitric Oxide	NTRM-81687	CC57165	1009 ppm
Carbon Dioxide	SRM-1674b	CLM007273	6.98 %

INSTRUMENTATION

COMPONENT	MAKE/MODEL	SERIAL#	DETECTOR	CALIBRATION DATE(S)
Methane	H. Packard-6890	US00001434	GC - FID	8/21/97
Nitric Oxide	Nicolet-760	ADM9600121	FTIR	8/27/97
Carbon Dioxide	Horiba-VIA-510	571417045	NDIR	7/25/97

THIS STANDARD WAS CERTIFIED ACCORDING TO THE EPA PROTOCOL PROCEDURES. DO NOT USE THIS STANDARD IF THE CYLINDER PRESSURE IS LESS THAN 150 PSIG.

ANALYST: TED NEEME

DATE:

8/27/97

APPENDIX C RAW FTIR DATA

ppnrv we outlet/ini Description: Chemilime time kiln																
Method title: Lime Uncond Starting Date/Time: Thu Jun 25 15:18:38 1998																
Time Fitename H2O (+-)H2O CO2 (+-)CO2 15:24:35 rn020007 163619.84 2032.88 175801.75 883.32	CO (+-)CO	NO (+-)NO 26.22 10.52	NO2 (+-)NO2 N2O 2.33 0.00	(+-)N2O NH3 1.08) 0.00		CH4 (+-)CH4 5.42 7.78		-)C2H6 C2H4 2.13 0.36	(+-)C2H4 H2C 0.80 0.2		TLD +-JACTLD 0.77 0.71	C4+ (+-)C4+ 0.80 0.52		H30H HCL (-	(+-)HCL 0.19
15:25:35 m020008 164553.98 2064.17 177294.94 896.16	13.37 0.50	25.90 10.70	0.21	2.18 0.00	1.17 0.00 1.17 0.00	0.50	3.44 7.96	3.18	2.18 0.36	0.82 0.1	5 0.13	1.34 0.70	0.79 0.53	1.73	1.34 15.12	0.19
15:27:35 m020010 170600.28 2150.65 180183.00 928.60	14.69 0.51	26.83 11.04	0.00	2.29 0.00 2.14 0.00	1.12 0.00	0.52	3.93 7.88 3.91 7.92	3.14	2.15 0.33 2.16 0.41	0.83 0.2 0.85 0.2	4 0.15	0.84 0.71 1.02 0.78	0.75 0.53 0.84 0.53	1.84 1.94	1.39 15.44 1.41 18.56	0.19 0.21
15:28:38 rn020011 173343.91 2161.15 181739.73 930.83 15:29:35 rn020012 174200.95 2205.69 182510.23 949.29	15.13 0.53 15.53 0.53		0.00	2.18 0.00 2.36 0.00	1.12 0.00 1.06 0.00		4.14 8.01 4.21 7.96	3.14 2.98	2.19 0.53 2.18 0.27	0.85 0.2 0.86 0.1		1.40 0.89 1.12 1.08	0.84 0.54 0.84 0.53	2.04	1.44 24.12 1.46 31.65	0.24
15:30:35 m020013 174840.13 2230.75 183456.13 959.52 15:31:35 m020014 155678.38 1942.72 172398.63 850.34	16.38 0.50 21.07 0.50	26.60 11.12	0.07	2.17 0.00 2.24 0.00	1.08 0.00	0.54	2.28 8.10 38.36 7.87	2.53 4.45	2.21 0.80 2.15 1.08	0.87 0.1 0.77 0.3	7 0.24	0.67 1.25 1.77 1.38	0.93 0.54 0.96 0.53	2.15	1.46 39.35 1.30 45.89	0.34
15:32:35 m020015 68734.70 1004.00 125198.12 479.80	31.13 0.30	15.50 7.64	0.00	1.58 0.00	0.86 0.00	0.27 2	40.77 4.05	12.06	1.11 3.64	0.44 0.4	2 0.19	1.05 0.99	1.87 0.27	1.33	0.72 30.75	0.27
15:33:35 m020016 124502.04 2037.63 181022.47 918.82 15:34:35 m020017 157047.25 1925.68 174025.95 841.81	14.67 0.44 13.11 0.49		0.00	2.00 0.00 2.19 0.00	1.03 0.00 1.12 0.00		02.65 5.95 38.26 7.56	6.75 4.54	1.63 0.49 2.07 0.48	0.84 0.1 0.77 0.0		1.05 0.88 0.99 0.79	1.31 0.40 1.04 0.51	2.15 1.73	1.43 26.00 1.30 19.93	0.24
15:35:36 rn020018 159901.83 1968.96 174647.63 857.60 15:36:35 rp020019 161612.03 2031.42 176281.67 884.31	12.76 0.52 13.02 0.52		0.00	2.33 0.00 2.12 0.00	1.23 0.00 1.14 0.00		15.51 7.87 7.39 7.44	3.79 3.07	2.15 0.37 2.04 0.41	0.78 0.1 0.81 0.1		1.17 0.68 0.65 0.70	0.84 0.53 0.73 0.50		1.31 16.34 1.36 14.29	0.18
15:37:35 m020020 162998.38 2036.04 177547.25 885.20	13.41 0.50	27.56 10.78	0.00	2.32 0.00	1.20 0.00 1.20 0.00		4.22 7.71	3.06	2.11 0.31	0.81 0.2	2 0.13	1.19 0.66	0.70 0.52	1.92	1.36 13.93	0.18
15:39:37 m020022 169618.59 2055.66 179334.68 888.37	14.06 0.50 14.70 0.52	28.00 10.99	0.21	2.25 0.00 2.22 0.00	1.10 0.00	0.50	3.11 8.10 3.88 7.81	3.23 3.00	2.21 0.25 2.14 0.52	0.81 0.2 0.81 0.1	9 0.14	0.73 0.70 0.83 0.73	0.80 0.54 0.84 0.52		1.38 15.43 1.39 17.66	0.19 0.20
15:40:36 rn020023 172188.23 2148.41 180163.28 928.30 15:41:38 rn020024 174335.75 2165.56 181021.30 931.90	15.64 0.53 16.30 0.54	27.16 10.96 27.48 11.11	0.00	2.15 0.00 2.10 0.00	1.12 0.00 1.09 0.00		3.78 7.69 2.43 7.97	2.81	2.10 0.50 2.18 0.61	0.84 0.1 0.85 0.2		0.70 0.84 0.70 0.96	0.91 0.52 0.83 0.53	1.96	1.42 22.26 1.44 28.92	0.23
15:42:37 rn020025 174774.98 2145.30 181555.23 922.82 16:12:38 rn020055 182360.83 2000.01 175498.97 870.04	16.88 0.54 13.01 0.50	28.62 11.21 25.23 10.55	0.00	2.34 0.00 2.17 0.00	1.13 0.00 1.13 0.00		3.29 8.53 8.91 7.64	3.30 3.11	2.33 0.48 2.09 0.32	0.84 0.2 0.79 0.2		0.60 1.17 1.06 0.72	0.79 0.57 0.85 0.51	1.87	1.43 37.23 1.32 18.92	0.32
16:13:37 m020056 165298.31 2066.98 177022.66 896.77	13.38 0.50	25.56 10.59	0.06	2.15 0.00	1.08 0.00	0.50	5.76 7.65	2.76	2.09 0.43	0.82 0.1	8 0.14	0.57 0.71	0.83 0.51	1.87	1.35 14.85	0.19
16:14:38 rn020057 167620.13 2118.14 178587.67 917.03 16:15:37 rn020058 170726.16 2151.78 179908.47 928.98	13.99 0.50 14.50 0.49		0.10 0.17	2.23 0.00 2.24 0.00	1.07 0.00 1.15 0.00	0.52	4.05 7.71 4.02 7.92	2.86 3.32	2.11 0.41 2.17 0.35	0.83 0.2 0.85 0.3		1.04 0.65 1.70 0.65	0.88 0.52 0.82 0.53	1.83	1.38 13.24 1.41 13.38	0.18 0.18
16:16:38 rn020059 172724.53 2193.74 181231.28 945.39 16:17:37 rn020060 174344.33 2202.50 182290.42 947.79	15.14 0.53 15.67 0.54		0.11	2.28 0.00 2.21 0.00	1.13 0.00 1.15 0.00		4.11 8.15 3.51 8.09	3.34	2.23 0.46 2.21 0.46	0.88 0.2 0.86 0.2		1.01 0.69 1.17 0.79	0.91 0.55 0.89 0.54		1.43 15.01 1.44 19.66	0.19 0.21
16:18:37 rn020061 174256.94 2207.63 182694.81 950.16 16:19:38 rn020062 167172.97 2130.78 179353.80 922.87	16.42 0.51 17.70 0.53	26.55 11.17	0.00	2.22 0.00 2.26 0.00	1.11 0.00 1.13 0.00		4.21 8.26 4.79 7.99	3.13 2.73	2.26 0.32 2.18 0.48	0.86 0.1 0.84 0.3	8 0.18	1.49 0.95 1.58 1.16	0.92 0.55 0.86 0.54	2.10	1.43 27.57 1.40 35.40	0.26
16:20:37 rn020063 75471.93 808.99 109330.31 383.76	39.53 0.32	12.80 7.02	0.00	1.62 0.00	0.89 0.00	0.21 2	65.60 4.39	13.34	1.20 5.16	0.35 0.7	3 0.18	1.44 0.96	2.01 0.29	0.87	0.53 29.10	0.26
16:21:38 rn020064 104926.76 2013.61 183658.23 925.98 16:22:37 rn020065 154868.09 1957.35 173918.94 857.38	15.77 0.41 13.10 0.45	26.24 10.33	0.00	1.84 0.00 2.16 0.00	0.97 0.00 1.09 0.00	0.48	23.80 5.29 46.96 7.27	7.20 4.72	1.45 0.71 1.99 0.53	0.84 0.1 0.78 0.0		1.42 0.86 1.50 0.79	1.48 0.35 1.06 0.49		1.45 24.02 1.32 20.60	0.23 0.21
16:23:38 rn020066 159389.44 1970.17 174531.09 859.40 16:24:37 rn020067 161431.27 2062.13 176168.92 897.83	12.89 0.49 12.99 0.51		0.08	2.24 0.00 2.20 0.00	1.02 0.00 1.12 0.00	0.48	7.32 7.84 7.45	3.42 2.99	2.00 0.41 2.04 0.33	0.78 0.1 0.82 0.1		1.58 0.75 1.11 0.68	0.91 0.49 0.81 0.50		1.33 16.91 1,34 15.14	0.20 0.18
16:25:37 rn020068 164482.42 2054.68 177849.83 892.09	13.52 0.50	26.20 10.65	0.00	2.20 0.00	1.14 0.00 1.18 0.00	0.50	5.04 7.76	3.21	2.12 0.38	0.81 0.0	9 0.12	0.99 0.65	0.86 0.52	1.88	1.36 14.38	0.18
16:27:37 rn020070 170229.89 2120.77 179894.33 916.00	14.85 0.52	26.74 10.91	0.00	2.28 0.00 2.35 0.00	1.15 0.00	0.51	3.25 8.08	3.08	2.16 0.38 2.21 0.43	0.83 0.0 0.83 0.2	5 0.14	1.07 0.70 1.19 0.75	0.83 0.53 0.89 0.54		1,38 15.41 1.39 18.61	0.19 0.20
16:28:38 rn020071 172423.41 2171.95 180678.56 936.25 16:29:38 rn020072 173806.52 2208.90 181266.13 951.00	15.42 0.51 15.96 0.55		0.13	2.36 0.00 2.18 0.00	1.11 0.00 1.07 0.00		2.76 8.05 3.59 8.04	2.84	2.20 0.51 2.20 0.45	0.85 0.2 0.87 0.2		1.21 0.89 1.31 1.09	0.98 0.54 0.99 0.54	2.00	1.42 24.66 1.42 31.95	0.24
16:30:38 rn020073 174079.52 2184.38 181688.13 940.22 17:00:39 rn020103 160609.72 2076.06 174795.36 904.58	16.40 0.51 13.00 0.47	27.51 11.16	0.17 0.01	2.29 0.00 1.96 0.00	1.10 0.00 1.01 0.00		2.67 8.36 10.08 6.63	3.04 2.62	2.28 0.49 1.87 0.54	0.88 0.1 0.82 0.0	6 0.24	1.56 1.25 1.34 0.82	0.92 0.56 0.88 0.46	2.06 1.97	1.44 40.18 1.37 20.92	0.34 0.22
17:01:39 m020104 163803.25 2078.34 176795.28 902.92	13.28 0.47	.25.88 10.64	0.00	1.96 0.00	1.08 0.00	0.51	4.69 7.65	2.92	2.09 0.24	0.82 0.0	6 0.15	1.10 0.78	0.83 0.51	1.88	1.35 19.16	0.21
17:02:39 rn020105 165990.53 2077.33 178495.03 900.65 17:03:38 rn020106 169304.50 2125.03 180218.22 818.61	13.81 0.50 14.19 0.51	26.75 11.00	0.00	2.24 0.00 2.20 0.00	1.08 0.00	0.51	3.03 8.13 4.42 8.16	3.08	2.22 0.38 2.23 0.37	0.82 0.1 0.84 0.1		1.61 0.78 1.49 0.83	0.85 0.54 0.81 0.55	1.80	1.37 19.57 1.40 22.33	0.21 0.22
17:04:42 rn020107 171735.17 2178.48 181509.73 939.65 17:05:48 rn020108 173272.08 2217.41 182274.17 955.13	14.85 0.51 15.56 0.52		0.12	2.11 0.00 2.27 0.00	1.09 0.00 1.13 0.00		3.07 8.23 3.23 8.53	2.94 2.95	2.25 0.46 2.33 0.39	0.86 0.1 0.87 0.1		1.17 0.95 1.05 1.11	0.91 0.55 0.92 0.57	1.93	1.42 27.37 1.43 34.31	0.26 0.30
17:06:45 rn020109 174772.02 2238.17 183219.36 962.77 17:07:44 rn020110 171891.94 2222.56 181874.06 958.53	18.05 0.53 16.31 0.52	27.59 11.25	0.02	2.15 0.00 2.16 0.00	1.12 0.00 1.12 0.00	0.54	3.33 8.49 3.83 8.16	2.79 2.45	2.32 0.49 2.23 0.52	0.88 0.0 0.87 0.1	8 0.25	1.36 1.30 1.27 1.50	0.90 0.57 0.90 0.55		1.46 42.42 1.45 51.19	0.35
17:08:45 m020111 85713.42 928.63 114463.87 435.69	39.71 0.34	14.65 7.39	0.00	1.89 0.00	0.98 0.00	0.24 2	62.01 5.14	13.73	1.41 5.17	0.40 0.5	3 0.23	1.34 1.22	1.71 0.34	0.83	0.60 40.68	0.41
17:09:45 rn020112 98144.73 1995.08 183594.56 923.89 17:10:45 rn020113 155159.50 2008.03 173922.78 879.35	16.36 0.41 12.81 0.49	25.52 10.26	0.00	1.76 0.00 2.20 0.00	0.98 0.00 1.08 0.00	0.49	39.48 5.20 48.82 7.43	8.30 4.77	1.42 0.71 2.03 0.35	0.84 0.1 0.80 0.0	6 0.18	1.48 1.02 0.91 0.93	1.57 0.35 1.14 0.50	2.15 1.76	1.46 30.22 1.31 26.34	0.28 0.25
17:11:45 rn020114 160378.83 1998.34 174321.91 870.03 17:12:44 rn020115 161735.19 2060.93 176392.02 897.06	12.46 0.46 12.88 0.48		0.00	2.23 0.00 2.21 0.00	1.04 0.00 1.06 0.00		18.25 7.65 8.75 7.53	3.52 2.79	2.09 0.39 2.06 0.27	0.79 0.1 0.82 0.1		1.36 0.83 0.78 0.75	0.95 0.51 0.91 0.50	1.77	1,32 21.71 1,34 19.23	0.22
17:13:45 rn020116 163983.06 2090.41 178071.80 908.02 17:14:45 rn020117 166650.97 2130.86 179443.30 923.35	13.35 0.51 14.09 0.47	27.14 10.74	0.08	2.24 0.00 2.14 0.00	1.09 0.00 1.07 0.00	0.51	4.82 7.89 3.02 7.60	3.16 2.74	2.16 0.32 2.08 0.27	0.83 0.1 0.84 0.2	5 0.14	1.26 0.76 1.35 0.80	0.88 0.53 0.87 0.51	1.96 1.98	1.36 18.22	0.20
17:15:46 rn020118 168250.84 2137.32 179589.89 924.80	15.08 0.47	26.94 10.83	0.13	2.17 0.00	1.04 0.00	0.52	5.04 7.72	3.15	2.11 0.35	0.84 0.2	9 0.17	0.91 0.87	0.86 0.52	1.89	1.39 23.98	0.22
17:16:45 rn020119 171178.08 2183.02 180827.17 942.08 17:17:45 rn020120 172924.41 2173.22 181056.38 936.38	18.01 0.49 18.71 0.51		0.02	2.32 0.00 2.19 0.00	1.03 0.00 1.06 0.00	0.53 0.52	4.63 7.85 4.40 7.82	3.13 3.14	2.15 0.39 2.14 0.54	0.88 0.2 0.85 0.3		1.20 0.91 1.51 0.86	0.92 0.53 0.93 0.52	2.24	1.44 24.22 1.44 23.58	0.25 0.23
17:18:45 rn020121 174334.08 2216.97 181644.52 954.03 17:48:45 rn020151 163052.88 2019.00 175031.47 877.75	20.39 0.52 13.08 0.48		0.00	2.06 0.00 2.26 0.00	1.06 0.00 1.06 0.00		4.13 8.27 8.71 7.44	3.14 2.80	2.26 0.53 2.03 0.51	0.87 0.3 0.80 0.1		1.33 1.01 1.15 0.75	1.00 0.55 0.87 0.50	2.12 1.76	1.43 27.84 1.32 17.86	0.27 0.20
17:49:45 rn020152 164951.55 2043.43 176484.14 886.83	13.43 0.49 13.79 0.52	25.80 10.58	0.02	2.11 0.00 2.08 0.00	1.08 0.00		5.74 7.64 3.68 7.80	3.00 2.94	2.09 0.35 2.13 0.41	0.61 0.1 0.82 0.1	1 0.14	1.09 0.71	0.84 0.51	1.83	1.35 15.75	0.19
17:51:47 m020154 170514.55 2099.06 179952.39 906.39	14.51 0.51	26.48 11.01	0.01	2.22 0.00	1.09 0.00	0.51	3.18 7.88	3,07	2.15 0.45	0.83 0.1	8 0.13	1.05 0.70	0.88 0.53	1.92 1.95	1.38 15.21 1.39 15.80	0.18 0.19
17:52:46 rn020155 173196.41 2183.67 181353.44 940.66 17:53:47 rn020156 174293.97 2233.55 182223.23 961.20	15.57 0.52 16.10 0.49		0.00	2.13 0.00 2.23 0.00	1.09 0.00 1.11 0.00		2.35 8.01 3.30 7.94	3.00 2.98	2.19 0.41 2.17 0.56	0.66 0.2 0.88 0.1		1.48 0.74 1.32 0.88	0.98 0.54 0.93 0.53	1.93 2.12	1.42 18.80 1.45 24.68	0.20 0.24
17:54:46 rn020157 175888.27 2250.88 183606.16 967.27	16.61 0.51 18.78 0.54		0.00	2.22 0.00 2.25 0.00	1.09 0.00 1.08 0.00		3.39 8.23 2.85 8.46	2.86 2.54	2.25 0.36 2.31 0.42	0.88 0.1 0.87 0.2		1.42 1.04 1.49 1.21	0.94 0.55 1.00 0.57	1.88	1.45 31.57 1.46 39.19	0.28 0.33
17:56:47 m020159 95742.05 1090.63 124319.28 506.32 17:57:46 m020160 78870.84 1729.01 168841.00 817.18	32.03 0.36 17.56 0.35	15.70 7.85	0.00	1.76 0.00 1.53 0.00	0.90 0.00 0.88 0.00	0.28 1	96.34 5.25 59.37 4.43	10.75	1.43 3.51 1.21 1.12	0.46 0.5 0.74 0.1	9 0.22	1.31 1.13 1.09 0.89	1.64 0.35 1.55 0.30	1.04	0.72 36.33 1.26 25.46	0.31
17:58:47 m020161 151313.89 1964.77 174076.45 863.49	12.79 0.45	25.28 10.33	0.00	2.20 0.00	1.09 0.00	0.48	60.75 7.05	5.08	1.93 0.24	0.79 0.0	0 0.16	1.32 0.86	1.13 0.47	1.78	1.33 23.31	0.23
17:59:46 m020162 160470.34 1963.21 173518.61 855.51 18:00:47 rn020163 159888.31 2051.00 175845.13 894.25	12.25 0.47 12.38 0.47		0.00	2.28 0.00 2.20 0.00	1.13 0.00 1.07 0.00		19.23 7.81 7.41 7.51	3.67 2.86	2.13 0.13 2.05 0.36	0.78 0.0 0.81 0.0		1.20 0.77 0.90 0.74	0.88 0.52 0.78 0.50	1.75 1.68	1.29 18.94 1.32 16.85	0.21
18:01:46 rn020164 163945.34 2072.37 177424.09 900.21 18:02:46 rn020165 166184.50 2110.57 178604.64 914.94	12.62 0.48 12.95 0.49		0.00	2.08 0.00 2.19 0.00	1.09 0.00 1.11 0.00		3.47 7.63 2.59 7.93	2.89 2.93	2.09 0.32 2.17 0.36	0.82 0.0 0.83 0.0		0.87 0.68 0.97 0.69	0.78 0.51 0.74 0.53	1.89	1.35 15.35 1.37 14.68	0.18 0.19
18:03:47 rn020166 170055.08 2175.81 179739.83 939.92	13.61 0.51	26.60 10.94	0.33	2.21 0.00	1.04 0.00	0.53	3.43 7.70	2.81	2.10 0.46	0.86 0.1	3 0.13	1.24 0.68	0.82 0.52	1.86	1.41 15.40	0.18
18:04:46 rn020167 172800.13 2197.77 180709.84 947.07 18:05:47 rn020168 173699.00 2250.94 181675.97 969.20		27.97 11.02	0.00	2.05 0.00 2.20 0.00	1.07 0.00 1.04 0.00	0.54	3.61 7.86 3.44 7.98	3.13	2.15 0.25 2.18 0.53	0.88 0.1 0.88 0.1	0 16	0.95 0.74 1.33 0.85	0.76 0.53 0.77 0.53	2.00 1.97	1.43 17.68 1.44 22.79	0.20
18:06:47 m020169 175445.42 2245.21 182254.39 965.22 18:36:49 m020199 161720.27 2067.00 173918.92 899.71	15.16 0.50	27.62 11.06	0.00 0.28	2.07 0.00 1.94 0.00	1.05 0.00 0.99 0.00		3.93 7.84 11.49 7.27		2.14 0.60 1.99 0.28	0.88 0.1 0.82 0.0		1.15 1.01 1.20 0.70	0.83 0.52 0.87 0.49	1.95 1.87	1.46 29.94 1.34 16.67	0.27 0.19
18:37:48 m020200 162956.09 2086.32 175668.22 907.10	12.49 0.45	25.02 10.50	0.04	1.85 0.00	1.00 0.00	0.51	5.57 7.31	2.79	2.00 0.42	0.83 0.1	3 0.14	1.60 0.72	0.82 0.49	1.83	1.36 15.92	0.19
18:38:49 rn020201 163302.63 2127.02 177977.80 924.50 18:39:49 rn020202 168856.06 2216.18 179363.27 958.57		25.38 10.75	0.00	2.02 0.00 1.98 0.00	1.01 0.00 0.97 0.00	0.54	3.44 7.26 2.71 7.54	2.85	1.98 0.40 2.06 0.63	0.84 0.1 0.87 0.2		1.62 0.76 1.33 0.76	0.73 0.49 0.79 0.50	1.86 1.78	1.39 16.85 1.42 17.27	0.20 0.20
18:40:49 rn020203 170828.56 2227.05 179983.09 961.39 18:41:49 rn020204 172892.13 2218.38 181071.36 955.87			0.15	2.10 0.00 2.10 0.00	1.04 0.00 1.06 0.00		4.10 7.78 3.46 7.88		2.13 0.59 2.16 0.58	0.88 0.1 0.87 0.2		1.64 0.78 1.70 0.87	0.84 0.52 0.85 0.53	1.94 1.92	1.41 18.96 1.44 23.91	0.21 0.23
18:42:48 m020205 174468.33 2254.75 181925.00 970.17	15.35 0.51	25.99 11.07	0.03	2.08 0.00	1.03 0.00	0.54	2.88 7.88	2.61	2.15 0.46	0.88 0.1	9 0.19	0.93 1.01	0.80 0.53	1.96	1.46 30.96	0.27
18:43:49 rn020206 175094.69 2240.28 182530.25 963.40 18:44:49 rn020207 115336.30 1384.69 140897.64 630.05		17.83 8.50	0.00	2.12 0.00 1.77 0.00	1.06 0.00 0.88 0.00	0.35 14	2.75 8.47 45.49 5.76	2.87 8.51	2.31 0.44 1.58 3.17	0.88 0.1 0.57 0.5	2 0.23	1.29 1.17 1.32 1.23	0.85 0.57 1.44 0.39	1.33	1.44 38.31 0.92 39.12	0.32
18:45:49 m020208 68060.90 1456.23 150593.34 696.44 18:46:49 m020209 145316.03 1966.62 173667.50 869.18	20.09 0.33 12.81 0.45		0.00	1.42 0.00 2.05 0.00	0.75 0.00 1.01 0.00		77.84 3.89 75.02 6.82	9.26 5.81	1.06 1.70 1.87 0.45	0.63 0.1 0.79 0.0		1.35 0.87 1.36 0.88	1.63 0.26 1.18 0.46	1.70 1.75	1.07 25.42 1.33 24.10	0.24
18:47:50 m020210 157839.36 1971.18 172273.52 861.07	12.41 0.46	25.62 10.24	0.04	2.02 0.00 2.08 0.00	1.05 0.00 1.06 0.00	0.48	22.99 7.42 6.40 7.46		2.03 0.42 2.04 0.27	0.78 0.0 0.81 0.0	9 0.14	1.30 0.74 1.45 0.72	0.91 0.50 0.81 0.50	1.64	1.28 19.31 1.31 16.66	0.20
18:49:50 rn020212 163080.39 2081.49 176038.13 904.89			0.02	2.15 0.00			3.29 7.61		2.08 0.36	0.82 0.0		2.09 0.70	0.75 0.51		1.35 15.68	0.19

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18:50:50 rn020213[164089.89] 2078.72[1	77529.67	902.86	13.20	0.49	26.74	10.75	0.00	2.04	0.00	1.08	0.00	0.51	2.92	7.67	3.03	2.10	0.49	0.82	0.13	0.14	1.51	0.71	0.76	0.51	1.82	1.36	16.05	0.19
18:51:49 rn020214 169748.16 2152.40 1	79019.36	930.07	13.80	0.48	26.55	10.80	0.11	1.99	0.00	1.07	0.00	0.52	2.81	7.69	3.10	2.10	0.52	0.85	0.14	0.14	1.14	0.74	0.86	0.52	2.02	1.40	16.44	0.20
18:52:50 m020215 171664.14 2199.44 1	80146.08	948.75	14.40	0.48	26.67	10.96	0.03	2.08	0.00	1.06	0.00	0.53	2.78	7.77	3.12	2.13	0.52	0.86	0.15	0.14	1.56	0.73	0.88	0.52	2.13	1.42	18.17	0.20
18:53:49 m020218 173560.81 2200.95 1	80898.59	947.79	15.02	0.51	26.97	11,01	0.11	2.09	0.00	1.07	0.00	0.53	. 3.96	8.03	3.11	2.20	0.47	0.86	0.23	0.16	1.18	0.84	0.88	0.54	2.08	1.42	22.60	0.23
18:54:50 rn020217 174348.27 2238.57 1	81658.83	963.31	15.47	0.50	27.57	11,13	0.00	2.13	0.00	1.10	0.00	0.54	2.54	8.26	3.10	2.26	0.32	0.88	0.18	0 20	1.60	1.03	0.80	0.55	1.93	1.43	30.09	0.28
Average 159439.20 2047.50 1	75532.26	891.32	15.66	0.49	25.72	10.61	0.05	2.12	0.00	1.07	0.00	0.50	26.64	7.51	3.86	2.05	0.65	0.81	0.18	0.16	1.23	0.86	0.95	0.50	1.87	1.35	23.24	0.23
Std. dev. 24925.55 268.48	13424.49	105.67	4.89	0.05	2.76	0.80	0.07	0.18	0.00	0.08	0.00	0.06	57.61	0.97	2.26	0.27	0.87		0.12	0.04	0.29	0.19	0.25	0.07	0.24	0.17	8.46	0.05
Maximum 175888 27 2254.75 1	83658.23	970.17	39.71	0.55	28.62	11.33	0.33	2.36	0.00	1.23	0.00	0.54	265.60	8.53	13.73	2.33	5.17	0.88	0.73	0.29	2.09	1.50	2.01	0.57	2.29	1.46	51.19	0.41
14tisissum 60060 00 600 00 4	00220 21	202.76	12 25	0.30	12.80	7 (2)	0.00	1.42	0.00	0.75	0.00	0.21	2.28	3.89	2.45	1.06	0.131	0.351	0.00	0.12	0.57	0.65	0.70	0.26	0.83	0.53	13 24	0.18

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A data in some wet															_															
utlet/inte						,			_																					
Description: Chemlin	ime lime kiln	<u> </u>	L					L																Γ						
Method title: Lime U		1	l		<u> </u>			1					L					· ·									L			
Starting Date/Time:	Thu Jun 25 15	5:18:38 1998																		1 1							1	1		
Time Fidenan	me H2O	(+-)H2O	CO2	(+-)CO2	co	(+-)CO	NO	(+-)NO	NO2	(+-)NO2	NZO	(+-)N2O	EH!A	(+-)NH3	CH4	(+-)CH4	C2H6	(+-)C2H6	C2H4	(+-)C2H4	H2CO	(+-)H2CO	ACTLD	+-VACTLD	C4+	(+-)C4+	СНЗОН	+-)CH3OH	HCL	(+-)HCL
	31 168011.38		181712.64		12.49	0.54	27.55		0.06	2.26	0.00	1.16	0.00		3.43		2.77	2.22	0.73		0.05	0.20	0.62	1.02	0.68				29.43	0.28
	32 169163.98		183299.00	940.06	12.82	0.52	28.12		0.00	2.33	0.00		0.00		3.30		3.08	2.35	0.43	0.86	0.00	0.23	0.45	1.21	0.72				38.94	0.33
	33 173001.52			973.77	13.27	0.51	26.42		0.00		0.00		0.00	0.54	2.46				0.57	0.89	0.04	0.28	0.47	1.49	0.72				48.71	0.40
			185106.09														2.52	2.25												
	34 174676.81			979.29	14.02	0.53	27.67		0.14	2.21	0.00		0.00	0.55	2.75		2.65	2.40	0.51	0.89	0.03	0.29	0.96	1.53	0.71				51.77	
	35 176354.38		187243.53	986.20	14,41	0.59			0.19	2.17	0.00	1.17		0.55	2.72		2.78	2,48	0.62	0.90	0.12		0.89		0.55				56.04	0.45
	36 177456.08		187941.94	1002.62	14.98	0.53			0.01	2.24	0.00	1.15			1.96		2.55	2.43	0.51	0.91	0.00	0.32	1.08	1.67	0.66				59.72	0.45
15:54:36 m02003	37 177399.64	2380.14	188562.97	1021.44	15.65	0.50	27.14	11.61	0.00	2.10	0.00	1.09	0.00	0.57	2.39	8.60	2.55	2.35	0.53	0.93	0.25	0.34	1.17	1.76	0.66	0.58	2.09	1.55	62.53	0.48
15:55:35 m02003	38 137532.78	1690.79	156792.84	752.83	32.83	0.48	22.12	9.39	0.00	1.97	0.00	1.09	0.00	0.42	148.75	7.36	9.50	2.01	3.69	0.69	0.52	0.30	1.01	1.58	1.39	0.49	1.64	1.14	57.18	0.43
15:56:36 m02003	39 61599.17	1652.37	156237.92	795,95	20.26	0.32	21.25	9.20	0.00	1.39	0.00	0.77	0.00	0.45	170.93	3.55	8.43	0.97	1.46	0.72	0.21	0.17	0.75	0.90	1.50	0.24	2.06	1.26	28.10	0.24
	150319.36		183560.31	956.13	12.81	0.43			0.00	2.03	0.00	1.12	0.00		89.53		6.45	1.91	0.35	0.87	0.06	0.18	0.75	0.96	1.22			1.48	28 42	0.26
	41 165055.97		179340.59	919.58	12.01	0.50			0.05	2.09	0.00	1.01	0.00		31.79		3.76	2.00		0.84	0.05	0.17	1.21	0.90	0.82				25.54	
			181022 81	940.66		0.48			0.04	2.18	0.00	1.01	0.00		13.39		2.93	1.98	0.57	0.86	0.00		0.95		0.76	0.49				
	165581.16				12.19																	0.18							26.04	
	167747.14		183067.50	948.51	12.48	0.48			0.00	2.21	0.00	1.08	0.00		5.04		2.83	2.14	0.45	0.86	0.05	0.19	0.85		0.63	0.52			28.82	
	169578.70		184068.22	952.90	12.97	0.52			0.00	2.14	0.00	1.20	0.00	0.53	3.22		2.76	2.21	0.49	0.87	0.09	0.23	0.98	1.18	0.60	0.54			36.58	
	171539.91		185165.08	947.68	14.43	0.52	28.87	11.37	0.00	2.20	0.00	1.09	0.00		1.94	8.41	2.58	2.30	0.53	0.86	0.07	0.24	0.53	1.25	0.71	0.56	2.14	1.48	39.94	0.34
16:03:37 m02004	46 176670.91	2269.87	185875.30	974.75	16.19	0.56	29.80	11.63	0.00	2.06	0.00	1.15	0.00	0.55	2.72	8.73	2.90	2.39	0.51	0.89	0.45	0.23	0.92	1.19	0.75	0.58	2.12	1.49	37.57	0.32
16:04:37 m02004	47 177957.56	2267.38	186299.33	972.57	17.79	0.54	29.88	11.57	0.21	2.27	0.00	1.16	0.00	0.54	2.89	8.93	2.94	2.44	0.50	0.89	0.12	0.25	1.10	1,32	0.78	0.60	2.08	1.48	43.30	0.36
	48 178956.53		186815.58	984 93	18.15	0.53			0.00	2.18	0.00	1.18	0.00		2.69	8.94	3.25	2.44	0.61	0.90	0.12		0.62		0.69				50.06	0.39
	49 179341.05		187312.19	982 69	17.50	0.57			0.22	2.48	0.00	1.28	0.00		2.95		3.40	2.58	0.45	0.89	0.14		1.35		0.70	0.63			54,70	0.43
	79 168432.09		181797.02	943 30	12.75	0.49			0.02	2.04	0.00	1.05	0.00		7.70		3.21	2.12			0.12		0.66		0.78				22.20	
				970.78							0.00	1.10			4.95	7.93				0.88										
	80 170637.75		183348.47		13.11	0.51			0.28	2.18			0.00				2.83	2.17			0.08		1.11		0.69				26.45	
	81 173102.56		184891.06	983.69	13.67	0.52			0.03	2.27	0.00	1.10	0.00		2.80		2.76	2.25	0.50	0.90	0.06		0.85		0.72				35.83	
	82 174982.33		185692.75	990.75	14.21	0.49			0.12	2.17	0.00	1.08	0.00		3.23		2.39	2.30		0.90	0.08		0.46		0.76				47.56	0.38
	83 177152.08		187198.56	1000.74	14.88	0.53			0.00	2.14	0.00	.1.06			2.58		2.60	2.34	0.52	0.91	0.18		1.19		0.69				52.57	0.42
	84 177846.09		187727.55	1020.77	15.45	0.54	27.55	11.54	0.08	2.13	0.00	1.07	0.00	0.57	2.17	8.62	2.54	2.36	0.44	0.93	0.00	0.31	1.39	1.60	0.78	0.58	2.18	1.53	55.28	0.43
18:42:39 m02008	85 177938.58	2365.90	188278.27	1014.84	15.86	0.52	28.30	11.64	0.21	2.22	0:00	1.15	0.00	0.57	2.87	8.82	2.67	2.41	0.49	0.92	0.13	0.33	0.82	1.71	0.72	0.59	2.14	1.54	58.93	0.46
	86 154182.98		176380.50	907.25	22.53	0.49			0.06	2.14	0.00	1.05	0.00	0.51	39.53	7.77	4.32	2.12	1.23	0.83	0.27	0.31	1.14		0.89				57.35	
	87 56308.09		131246.70	589.47	27.52	0.31			0.00	1.20	0.00	0.63	0.00		212.65	3.48	10.30	0.95	3.38		0.36		0.84		1.74	0.23			27.53	0.26
	88 135373.66		188860.73	1007.58	13.15	0.43			0.18	2.02	0.00	1.00			105.15		6.90	1.71	0.75		0.07	0.18	0.98		1.30				26.73	0.26
	89 165186.88		179039.58	916.38	11.96	0.49			0.10	2.29	0.00	1.11			37.26		4.54	2.12	0.44	0.83	0.13		1.00		0.92				23.80	0.20
				- 10,00							0.00																			
	90 166365.25		180800.06	931.72	11.71	0.49			0.00	2.20		1.09			15.88		3.49	2.13		0.85	0.01		0.63		0.76				22.69	0.23
	91 166595.95		182714.27	956.15	11.94	0.51			0.00	2.32	0.00	1.08			5.42		3.13	2.21	0.54	0.87	0.01				0.68				27.04	0.26
	92 168485.97		184372.95	964.17	12.43	0.51			0.11	2.28	0.00	1.14			3.12		2.82	2.22	0.52	0.88	0.03		0.31		0.65				34.87	0.30
6:50:39 rn02009	93 171263.11	2264.97	185205.66	977.37	13.32	0.52	28.64	11.33	0.00	2.14	0.00	1.13	0.00	0.55	2.44	8.39	2.75	2.29	0.38	0.89	0.00	0.27	0.99	1.40	0.73	0.56	2.09	1.48	46.56	0.38
16:51:38 rn02009	94 173558.27	2245.27	185305.33	966.88	13.87	0.50	29.19	11.38	0.00	2.24	0.00	1.13	0.00	0.54	1.95	8.76	2.78	2.40	0.57	0.88	0.10	0.28	0.87	1.49	0.71	0.59	2.22	1.47	51.42	0.40
16:52:40 rn02009	95 175867.11	2303.66	186744.97	989.97	14.57	0.52	29.00	11.43	0.04	2.18	0.00	1.06	0.00	0.55	2.37	8.50	2.51	2.32	0.55	0.90	0.12	0.30	1.19	1.58	0.73	0.57	2.32	1.52	55.21	0.43
18:53:39 m02009	96 176720.50	2344.86	187140.91	1006.91	15.47	0.53	29.70	11.50	0.21	2.18	0.00	1,14	0.00	0.56	2.98	8.71	2.55	2.38	0.54	0.92	0.15	0.32	1.08	1.69	0.77	0.58	2.11	1.50	59.45	0.46
	97 177489.16		187402.61	1009.04	16.30	0.52	28.97		0.08	2.12	0.00	1.06	0.00	0.56	2.86	8.53	2.37	2.33	0.73	0.92	0.07	0.34	1.92	1.78	0.82				82.43	
	27 154603.64		154473.05	828.80	11.46	0.45	20.38		0.08	2.06	0.00				10.89		2.60	1.89	0.40	0.75	0.08	0.14	1.62	0.72	1.03	0.46	1.50	1.16	18.15	
	28 156474.72		156109.50	816.11	11.91	0.47			0.00	2.08	0.00	1.09		0.46	8.51		2.97	2.07	0.47	0.74	0.00	0.14	1.68		0.96	0.51		1113	16.79	0.20
	29 158341.08		157386.58	817.63	12.10	0.47			0.00	2.09	0.00		0.00		3.35		2.86	2.09	0.41	0.74	0.01	0.14	1.48		0.94				17.45	0.19
	30 161219.25		158392.11	817.85	12.66	0.47			0.00	2.19	0.00	1.20		0.46	3.87		2.91	2.18			0.17		2.10		1.01				21.67	0.22
17:28:45 rn02013	31 161518.81	1866.45	159545.17	812.57	13.36	0.47	22.56	9.58	0.07	2.30	0.00	1.31	0.00	0.45	3.67	8.33	2.98	2.28	0.53	0.74	0.09	0.20	1.08	1.02	0.93	0.56	1.55	1.14	30.70	0.28
17:29:46 rn02013	32 162613.58	1896.80	159972.06	824.95	14.70	0.50	21.27	9.64	0.08	2.01	0.00	1,17	0.00	0.46	2.98	7.92	2.47	2.17	0.62	0.75	0.20	0.22	1.40	1.16	1.00	0.53	1.61	1.19	37.04	0.31
17:30:45 rn02013	33 162530.81	1867.33	160451.91	812.20	16.05	0.51	21.57	9.66	0.00	2.03	0.00	1.18	0.00	0.45	3.63	8.21	2.50	2.25	0.65	0.74	0.15	0.24	1.67	1.27	1.03	0.55	1.57	1.17	41.11	0.34
17:31:45 m02013	34 161338.27	1866.23	160026.41	812.61	15.88	0.49	21.14	9.59	0.00	2.03	0.00	1.12	0.00	0.45	2.42	7.84	2.41	2.14	0.38	0.74	0.18	0.25	1.73	1.33	0.95	0.52	1.77	1.19	44.25	0.36
17:32:45 rn02013	35 84163.10	876.17	99613.05	411.78	29.22	0.36	10.27	6.86	0.00	1.73	0.00	0.94	0.00	0.23	180.99	4.68	9.62	1.28	3.54	0.37	0.47	0.21	1.64	1.09	1.59	0.31	0.75	0.50	34.13	0.30
17:33:46 rn02013			168719.31	838,56	15.04	0.39	23.03	9.56	0.00	1.63	0.00	0.94	0.00	0.47	137.01	5.04	7.76	1,38	0.77	0.76	0.16	0.18	1.21	0.96	1.67	0.34	1.83	1.26	28.48	0.26
17:34:45 rn02013			153117.78	737,99	11.47	0.42			0.00		0.00	1.10			46 87	7.03	4.35	1.92		0.67	0.11	0.19	0.86		1.19	0.47			28.33	0.26
17:35:45 m02013				914.29	11.77	0.47			0.03	1.92	0.00	1.05		0.51	9.64		3.01	2.12			0.06	0.18	1.37	2.22	0.78	0.52	1.87	1.37	26.79	0.25
17:36:45 rn02013			181912.80	915.64	11.96	0.47			0.03	2.16	0.00	1.06			2.97		2.72	2.17			0.00	0.19	1.05		0.70	0.53		1.42	28.49	0.23
			183298.30	935.64	12.37	0.51			0.17	2.08	0.00	0.99		0.52	2.79		2.72	2.17		0.85	0.07	0.19	1.03		0.71	0.53		1.42	34.34	
17:37:45 rn02014															170															0.30
7:38:45 rn02014			185175.20	962.36	12.88	0.48			0.05	2.10	0.00	1.04			777		2.52			0.88	0.04	0.23	0.36		0.70				38.96	0.32
7:39:45 rn02014			186166.06	985.76	13.45	0.49			0.15		0.00		0.00		3.70		2.71	2.20			0.14	0.23	0.36		0.75				38.78	0.33
7:40:46 rn02014			186994.42	991.48	14,10	0.49			0.45		0.00		0.00		2.56		2.76	2.29	0.52		0.08	0.25	0.16		0.71				44.75	0.36
7:41:45 rn02014			187957.22	992.34	14.69	0.50			0.28		0.00	1.11	0.00	0.56	2.31		2.47	2.29	0.50	41-4	0.04	0.29	0.31		0.71	0.56			50.44	0.42
7:42:45 rn02014			188353.72	991.26	15.15	0.51			0.28		0.00	1.06	0.00	0.55	2.84		2.55	2.42		-100	0.09	0.30	0.47		0.72				55.28	0.43
18:12:49 m02017			181481.27	964.93	12.60	0.47	26.32	10.89	0.15	2.13	0.00	1.04	0.00	0.54	7.83	7.63	2.89	2.09	0.53	0.88	0.16	0.15	1.03	0.81	0.81	0.51	1.89	1.46	21.27	0.22
8:13:49 m02017	76 169905.73	2252.74	183027.11	973.29	12.95	0.49	26.43	11.03	0.03	1.96	0.00	1.01	0.00	0.54	3.89	7.72	2.93	2.11	0.67	0.89	0.18	0.17	1.03	0.88	0.73	0.52	2.02	1.48	23.58	0.24
8:14:48 m02017			185181.59	1004.67	13,64	0.51			0.18	2.08	0.00	1.05	0.00	0.56	3.29	8.04	2.67	2.20		0.91	0.07	0.19	1.32		0.76	0.54		1.51	30.04	0.27
8:15:48 rn02017			186161.97	1009.24	14.47	0.52			0.24		0.00		0.00		1.57	8.49	2.72	2.32		0.92	0.09	0.24			0.79				40.61	0.34
8:16:49 rn02017			187509.06	1029.51	15.30	0.50			0.15		0.00				2.87		2.63	2.36		0.94	0.00	0.29	1.03		0.76	0.57		1.55	50.86	
									0.00	2.07	0.00			0.58	3.92		2.74	2.39		0.94	0.00		1.21		0.74					0.41
	80 178818.50		188320.08	1029.45	15.82	0.54																0.29				0.59			53.72	0.42
8:18:49 rn02018			188987.45	1031.14	16.02	0.51	27.89		0.27	2.05	0.00	1.08		0.58	2.59		2.40	2.39			0.06	0.32	0.99	1.67	0.73	0.59		1.56	57.00	0.45
3:19:48 rn02018			186006.72	1011.50	16.73	0.57	26.42	11.29	0.00	2.33	0.00	1.11	0.00	0.57	2.74		2.28	2.29	0.68	0.92	0.18	0.32	1.30		0.77	0.56	2.12	1.52	58.67	0.45
8:20:49 m02018	83 59993.44	723.06	101014.08	348.93	37.33	0.28	10.99	6.50	0.00	1.30	0.00	0.75	0.00	0.20	237.33	3.75	12.03	1.03	4.77	0.32	0.53	0.20	1.71	1.03	1.61	0.25	0.74	0.46	32.37	0.28
8:21:48 m02018	84 112088.63		201081.45	1173.08	15.57	0.43			0.07	1.81	0.00	0.99	0.00	0.66	153.92	5.45	8.85	1,49	0.93	1.07	0.00	0.17	1.60		1.55	0.36	2.60	1.82	25.62	0.24
8:22:49 m02018			178788.30						0.19	2.08	0.00	1.07	0.00		41.94	7.77	4.46	2.12		0.86	0.00	0.17	0.94	0.92	1.01	0.52		1.40	25.59	0.25
8:23:49 rn02018					12.10			_	0.05	2.04	0.00		0.00		14.10		3.14	2.08	0.49	0.87	0.06		0.91	0.89	0.82	0.51	1.93	1.43	23.69	0.24
8:24:49 m02018													0.00																	
						0.53			0.00		0.00	1.06			4.32		2.79	2.14	0.58	0.88	0.01		1.09		0.67			1.46	25.91	0.25
8:25:49 rn02018						0.51			0.16		0.00		0.00		1.65		2.68	2.23	0.57	0.89	0.13		0.65		0.64	0.55		1.47	33.11	0.29
8:26:48 m02018	89 170787.31		185119.00		13.01	0.50		11.27	0.22	2.13	0.00	1.13	0.00		1.97		2.67	2.27	0.42		0.07	0.21	1.50	1.08	0.64	0.56	2.11	1.49	33.29	0.29
8:27:49 rn02019	90 176954.66	2337.95	185749.73	1003.74	13.71	0.55	29.29	11.43	0.08	2.14	0.00	1.14	0.00	0.56	2.10	8.61	2.93	2.35	0.61	0.91	0.14	0.20	1.13	1.04	0.75	0.58	2.10	1.50	32.03	0.28
			186701.64			0.54			0.33		0.00		0.00		2.49		2.90	2.38.			0.11	0.23	1.23		0.73				39.17	
8:28:48 rn02019	9111/8149.60		187313.23			0.54			0.18	2.21	0.00		0.00		2.42		2.59	2.40	0.56		0.15	0.29	1.43		0.75				50.40	0.41
						0.53			0.21	2.27	0.00	1.08	0.00	0.58	3.75		2.73	2.38	0.74		0.16	0.30	1.46		0.71				54.70	0.43
18:29:49 rn02019	92 178722.98		197561 40							4.41	0.00	1.00		0.50	3,13	. 0.11	2.13	2.00	0.14		2.131	0.30	1.70	1,00	9.71	0.00	4.40	1.03		U.43
18:29:49 rn02019 18:30:48 rn02019	92 178722.98 93 179227.86	2400.73	187561.48							2 10	0.00	1 00 1	0.00	0.52	24 74	7 pc	2 50	2 451	0.72	0.05	0.14	0.22	1.04	1 24	0.00	0.53	100	9.44	20.70	0.25
18:29:49 rn02019 18:30:48 rn02019 Average	92 178722.98 93 179227.86 162246.05	2400.73 2146.08	177891.39	931.64	15.12	0.49	26.45	10.82	0.09	2.10	0.00	1.08	0.00	0.52	24.71		3.58	2.15	0.73		0.11	0.23	1.04		0.86	0.53			38.72	0.33
18:29:49 rn02019 18:30:48 rn02019 Average Std. dev.	92 178722.98 93 179227.86 162246.05 27115.30	2400.73 2146.08 312.92	177891.39 17470.28	931.64 125.00	15.12 4.55	0.49 0.05	26.45 3.82	10.82 1.08	0.09 0.10	0.21	0.00	0.10	0.00	0.07	52.94	1.20	2.08	0.33	0.77	0.11	0.11	0.06	0.40	0.31	0.27	0.08	0.30	0.21	13.13	0.08
Std. dev. Maximum	92 178722.98 93 179227.86 162246.05	2400.73 2146.08 312.92 2569.55	177891.39 17470.28 201081.45	931.64 125.00 1173.08	15.12 4.55 37.33	0.49 0.05 0.59	26.45 3.82 31.09	10.82 1.08 11.91	0.09 0.10 0.45	0.21 2.48		0.10 1.31	0.00	0.07 0.66		1.20 9.42	2.08 12.03		0.77 4.77	0.11 1.07		0.06 0.34	0.40 2.10	0.31 1.78		0.08 0.63	0.30 2.60	0.21 1.82	13.13 62.53	

APPENDIX D FTIR FIELD DATA SHEETS

Facility	Chemline
Stack ID	Inlet loutlet
Date	6/25/99
Run Number	1- Uncond.

FTIR Temperature Readout Sheet

Recorded By	SPL							Temperatu	ure (deg. F)						i literati	
		Time	(Time	Time	Time	Time	Time	Time	Time	Time	Time	Time	Time	Time	· Time	Time
Channel	Description	IAIR	1530	1342	1800	1615	1630	1645	1300	1815	130	1845	1800	1812	1830	1845
1	Inlet Stack	290	234	230	267	222	232	207	247	286	301	264	238	255	270	228
2	Outlet Stack	230	231	250	23	233	240	239	237	237	241	231	229	229	231	235
3	Inlet Probe	344	345	344	345	344	344	345	343	243	346	342	344	341	341	242
4	Outlet Probe	344	348	347	247	345	347	346	348	3,43	349	347	346	347	346	347
5	Inlet Filter	339	340	340	335	340	338	342	343	337	337	338	335	339	338	345
6	Outlet Filter	348	349	349	249	349	349	349	349	346	350	349	350	349	345	347
7	Inlet HT	287	300	302	302	299	296	294	289	286	287	287	287	286	286	286
8	Outlet HT	354	350	356	356	355	356	356	357	359	359	358	319	328	336	341
9 .	Inlet Pump	263	246	254	265	259	277	275	251	269	253	266		257	273	266
10	Outlet Pump	317	318	318	327	334	326	334	327	323	312	322	325	320	3//	324
11	FTIR Pump	246	260	270	26)	250	259	248	761	253	250	263	265	251	242	262
12	Pump Box	112	120	118	117	117	122	114	NA	113	118	119	117	116	117	114
13	Extra HT	218	224	287	287	287	287	288	289	289	289	290	290	290	290	289
14	FTIR Jumper	322	324	325	325	325	325	325	326	338	328	377	328	327	326	326
15	Pump Jumper	313	330	331	33)	331	331	331	333	335	332	332	333	331	330	331
16	Hot Box	354	352	354	356	353	354	355	356	355	357	356	356	253	355	356
17	Hot Box	247	249	249	249	249	249	249	250	250	250	250	250	250	249	250
18	Extra HT	300	299	299	300	300	302	303	303	301	302/	202	303	302	302	301
19	Electronics Box	४५	85	36	87	87	87	87	89	88	2 2	80	89	89	90	89
20	`											<u></u>				

Facility	Chemline
Stack ID	Inlet loutlet
Date	6/25/98
Run Number	L-conditioned

FTIR Temperature Readout Sheet

Recorded By	SIL		1			12.23 23.		Temperatu	re (deg. F)		E AU TOTAL					
		Time	Time	Time	: Time	Time	Time	Time	Time	Time	Time	Time	Time	Time	Time	Time
Channel	Description	1245	1300	1345	140 134		M20,									
1	Inlet Stack		291	204	226	248										
2	Outlet Stack	223	243	237	22^{2}	221										
3	Inlet Probe	340	344	342	241	340										
4	Outlet Probe	345	345	347	536	341										
5	Inlet Filter	34)	241	342	330	339										
6	Outlet Filter	348	346		343	343										
7	Inlet HT	276	284	204	185	286										
8	Outlet HT	345	345	345	351	351										
9	Inlet Pump	242	251	261	223	234					· · · · · · · · · · · · · · · · · · ·					
10	Outlet Pump	315	319	321	3,4	270			·							
11	FTIR Pump	236	240	173	23[
12	Pump Box	104	112	115	109	106										
13	Extra HT	274	275	276	276	279										
14	FTIR Jumper	327	328	328		322	ļ									
15	Pump Jumper	327	327	327	327	316									·	
16	Hot Box	254	354	354	_	355										
17	Hot Box	241	249	248	248	2u4										
18	Extra HT	297	296	297	297	299										
19	Electronics Box	78	79	90	81	82										
20			<u> </u>													

Facility	Chem line
Stack ID	INlet SouTlet
Date	6/25/98
Run Number	1-UNCOND

FTIR Temperature Readout Sheet

Recorded By	D.94.							Temperatu	re (deg. F)				Sec. 600			
to the second se							Time				Time	Time	Time	Time	f Time	Time
Channel	Description	19:00	19:15	19:30	19:45	20:00	70:15	2030	2045	2100						
1	Inlet Stack	225														
2	Outlet Stack	237														
3	Inlet Probe	343							· · · · · · · · · · · · · · · · · · ·					"		
4	Outlet Probe	345									ļ					
. 5	Inlet Filter	343														
6	Outlet Filter	347														
7		285														
. 8	Outlet HT	345														
9	Inlet Pump	251									ļ					·
10	Outlet Pump	329														
11	FTIR Pump	255														
12	Pump Box	116														
13		288														
14	FTIR Jumper	326														
15	Pump Jumper	330														
16	Hot Box	357				•										
17	Hot Box	250			`											
18	Extra HT	301														
19	Electronics Box	89														
20									·	·						

APPENDIX E PRE-TEST CALCULATIONS

Below are the results of the Method 320 pre-test calculations for this test program. The calculations are organized by appendix as found in the FTIR Protocol. These calculations were originally taken from the Secondary Aluminum HCl program from late 1997.

Appendix B

Potential Interferant Calculations:

These calculations determine potential **spectral** interferants for the analytes of interest (i.e., HCl). The results for HCl are given in the table below. The analysis region for HCl is not given since it is considered proprietary information.

TABLE 1
Interferant Calculations

Analyte	Concentration	Band area	IAI/AAI	Average absorbance
HCl (target)	0.1 ppmv	0.0005436	-	0.00000322
H ₂ O (potential interferant)	20%	0.2213	407	0.00131
CO ₂ (potential interferant)	20%	0.000002	0.0036	
H ₂ CO (potential interferant)	1 ppmv	0.0002100	0.386	1000年1月1日 1000年1月1日
CH ₄ (potential interferant)	20 ppmv	0.0105	19.3	0.00006213
in the second se			AVT	0.00137

Note: compounds in bold are known interferants. AVT is computed from target and known interferants.

Known interferant criteria is IAI/AAI > 0.5

From the Table, two potential interferants are identified: H₂O and CH₄.

Appendix C

Noise Level

This calculation determines instrumental noise level in the spectral analysis region for HCl. For a 1 minute integration time, the RMS noise is found to be 0.00022 (absorbance units) in the HCl spectral analysis region by the procedure given in Appendix G.

Appendix D

Estimating Minimum Concentration Measurement Uncertainties (MAU)

The result for HCl is:

MAU (HCl) = 0.4 ppmv.

This value is computed using the formula given in Appendix D. However, this value is derived using band area calculations. The FTIR spectral data in this field study are analyzed by classical least squares (CLS), not band areas. CLS derived minimum measurement uncertainties for HCl are on the order of 0.1-0.2 ppmv for this test program.

Appendix E

Determining Fractional Reproducibility Uncertainties (FRU)

This calculation estimates the uncertainty in analysis, using band areas, of two sequentially measured CTS spectra collected immediately before and after the HCl reference spectrum. The calculation is performed in the analysis region used for HCl. The result is:

FRU (HCl region) = 0.093.

The corresponding value using CLS is somewhat lower. For most analytes of interest, FRU usually falls between 0.001 and 0.04 using CLS.

Appendix F

Determining Fractional Calibration Uncertainties (FCU)

This section determines the fractional calibration uncertainties when analyzing each reference spectrum. These results will be applied to the compounds analyzed in the HCl analysis region. The table below gives the results.

TABLE 2 FCU Determination

Analyte	ASC (ppm)	ISC (H₂O)	ISC (HCl)	ISC (CH ₄)	FCU	AU
H ₂ O	113000	115000	0.000	0.000	-1.7%	-
HCl	253	-22.5	254	0.000	-0.4%	30%
CH_4	491	-23.0	0.000	493	-0.2%	-

Appendix G

Measuring Noise Levels

The result of this calculation is given under the Appendix C heading.

Appendix H

Determining Sample Absorption Pathlength (Ls) and Fractional Analytical Uncertainty

Since the HCl reference spectrum used in this program were measured at the same pathlength to be used during testing, these calculations are not required.

APPENDIX F POST-TEST CALCULATIONS

Below are the results of the Method 320 post-test calculations for this test program. The calculations are organized by appendix as found in the FTIR Protocol. Since classical-least-squares (CLS) is used for analysis, the CLS-equivalent calculations are used, since in some cases, the FMU values using band-areas can differ as much as an order of magnitude compared to CLS-derived results.

Appendix I

Determining Fractional Model Uncertainties:

These calculations determine the fractional error in the analysis for the analytes of interest (i.e., HCl). The results for HCl are given in the table below for 1 spectrum selected from the inlet and outlet test. In order to achieve results that are consistent with the CLS analysis approach, the CLS equivalent of the calculation was performed. This is simply the reported analysis error divided by the HCl concentration.

TABLE 1

FMU Calculation for HCl -Chemlime

Spectral File Name	Inlet/Outlet	Error (ppm)	Concentration (ppm)	FMU
RN020005.spa	Outlet	0.23	22.6	0.010
RN020029.spa	Inlet	0.23	22,7	0.010

Error is 95% confidence interval reported by CLS software.

Appendix J

Overall Concentration Uncertainty

The CLS equivalent of overall concentration uncertainty is simply the error reported by the CLS software. The results for this test program are found in Table 1, above.