SILICA TESTING TASK FORCE REPORT

Community Environmental Working Group

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List of Acronyms

ACFM	Unit of flow; Actual Cubic Feet Per Minute
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
°C	Unit of Temperature; degrees Celsius
CEWG	Community Environmental Working Group
CDC	Centers for Disease Control
CFR	Code of Federal Register
CO	Carbon Monoxide
CO_2	Carbon Dioxide
Conc.	Concentration
DHAC	Division of Health Assessment and Consultation
DSCFM	Unit of Flow; Dry Std. Cubic Feet Per Minute (corr. To 29.92” Hg & 25°C)
EPA	Environmental Protection Agency
F11X-F-side	Fab 11X Fab Side location designation
F11X B-side	Fab 11X Bridge Side location designation
°F	Unit of Temperature; degrees Fahrenheit
HMDS	hexamethyldisilazane
Lbs/hr	Unit of emissions; pounds per hour
LOD	Limit of detection
LOQ	Limit of Quantitation
MW	Molecular Weight
NA	Not Applicable
ND	Non-Detected (value below the analytical/instrument limit of detection)
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
TPY	Unit of emissions; Tons per Year
ppm	Unit of concentration; parts per million
RM	Reference Method
RCTO	Recuperative Thermal Oxidizer
-RO	Rotor Outlet, synonymous with Wheel Exhaust of the Munters Systems Exhaust measurement point prior to common wheel exhaust manifold and stacks
SCFM	Unit of Flow; Std. Cubic Feet Per Minute (corr. To 29.92” Hg & 25°C)
SOP	Standard Operating Procedure
SS	Stainless Steel
STTF	Silica Testing Task Force
-TO	Thermal Oxidizer (separate stack designation on MUNTERS systems)
TFE	Teflon
µg	microgram
$\mu g/m^3$	microgram per cubic meter
QA	Quality Assurance
QC	Quality Control
VOC	Volatile Organic Compound (synonymous with Total Hydrocarbon)
WHEEL	Represents the exhaust of the Concentrator of the Munters System Further identified as the Rotor Outlet and also the fresh air exhaust
XRD	X-Ray Diffraction Analysis

1.0 Executive Summary

Intel's potential to emit crystalline silica to the air has concerned diverse interests, including Intel, for years. By varied means, the concerns are voiced repeatedly – to Intel, in newspapers, in a published book, to the N.M. Air Quality Bureau, to the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), and repeatedly at public meetings of the Community Environmental Working Group (CEWG). The public concerns voiced to the ATSDR led that agency to recommend more testing of crystalline silica from the stacks at Intel.

To address these concerns, the CEWG appointed a Silica Testing Task Force (STTF) to design and carry out a program which would test the emissions from the Intel thermal oxidizers emissions for crystalline silica. The primary objective of the testing was to determine whether crystalline silica concentration at-the-fence were above a CEWG provisional level. If the concentrations were above the provisional level, further studies would be conducted to identify the validity of the provisional study and other factors that influence the health risks that might be posed by the emissions.

STTF developed a sampling program that was carried out with the assistance of an Intel contractor Environmental Resources Management (ERM) and the National Institute for Occupational Safety and Health (NIOSH). ERM used standard stack sampling techniques to collect filter samples from Intel recuperative thermal oxidizers (RCTO) stacks while being observed by citizen volunteers. Because the sampled gas temperatures are too high to permit the use of the filters normally used for samples for X-Ray Diffraction Analysis (XRD) analysis of crystalline silica, a modified approach to insure field sampling compatibility with silica specific analyses was developed by ATSDR[1], ERM, and NIOSH[2] crystalline silica expert Rosa Key-Schwartz. The stack sampling was carried out using Environmental Protection Agency (EPA) stack-sampling techniques and measurements that were closely observed. All five RCTO stacks were sampled simultaneously four times (test runs) for an extended period to include representative periods of the day.

The collected filters were sent to NIOSH with careful chain of custody procedures. Measureable crystalline silica concentrations were found on only one of the filters and the measured level was far below the CEWG provisional level. The highest estimate of emissions estimates of the crystalline silica consistent with the data were very low so that very much higher levels of hexamethyldisilazane (HMDS) could be used without approaching the CEWG provisional level. Even the highest estimate of emissions consistent with the measured data in this silica testing program would have to be 15,000 times higher to approach the CEWG provisional level. As a further check at-the-fence concentrations with the use of previously developed dispersion models

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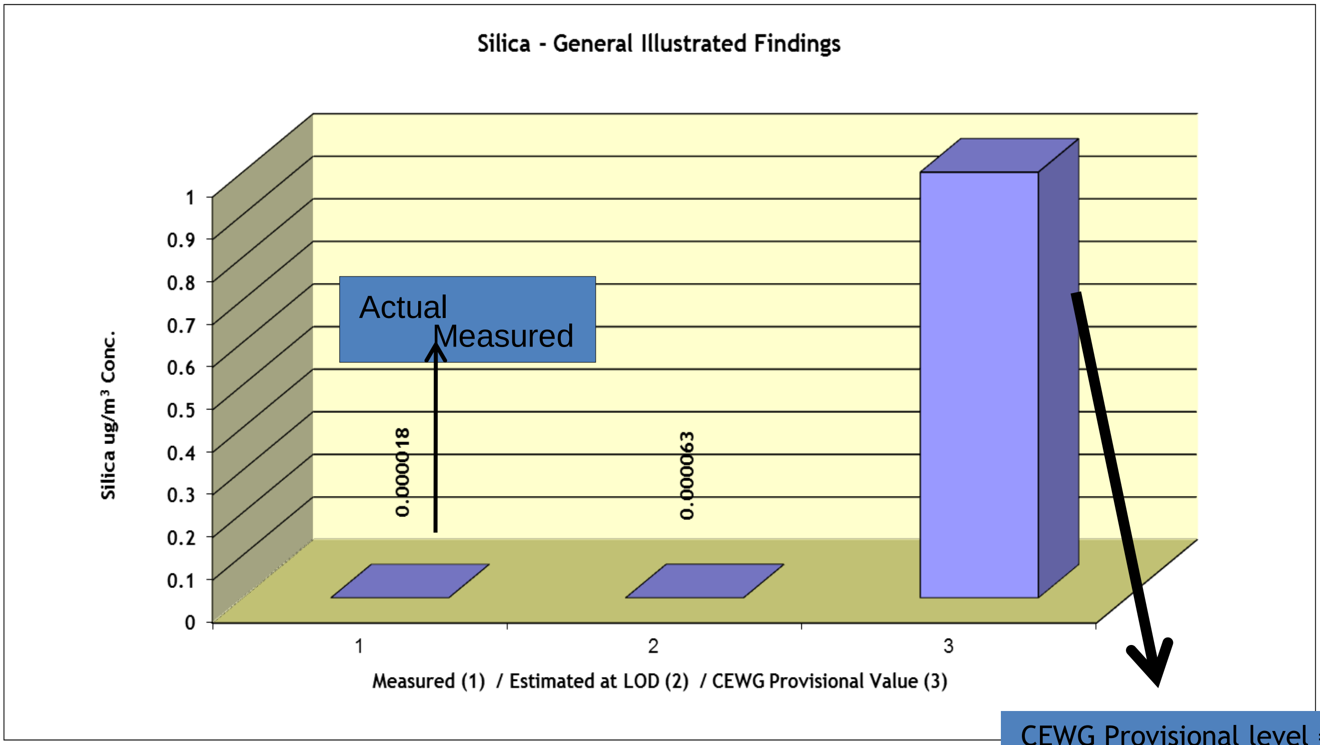
[1] See www.atsdr.cdc.gov

[2] See www.cdc.gov/NIOSH

were estimated under the assumption that all of the particulate matter was crystalline silica. The result was still quite low compared to CEWG provisional level.

Crystalline Silica was found in only 1 of the 20 collected stack samples from the five (5) Intel RCTO’s;

- 310 µg found on one sample = 103 µg/m^3 volume in stack
- The detected value equates to 0.0000177 µg/m^3 at fence line (55,000 times less than the CEWG’s provisional level)
- If all other non-detect samples @ level of detection added together = 0.0000634µg/m^3 at fence line (15,000 times less than the CEWG provisional level)
- CEWG Provisional level = 1.0 µg/m^3 at fence line



CEWG Provisional level = 1.0 µg/m^3 at fence line

Figure 1

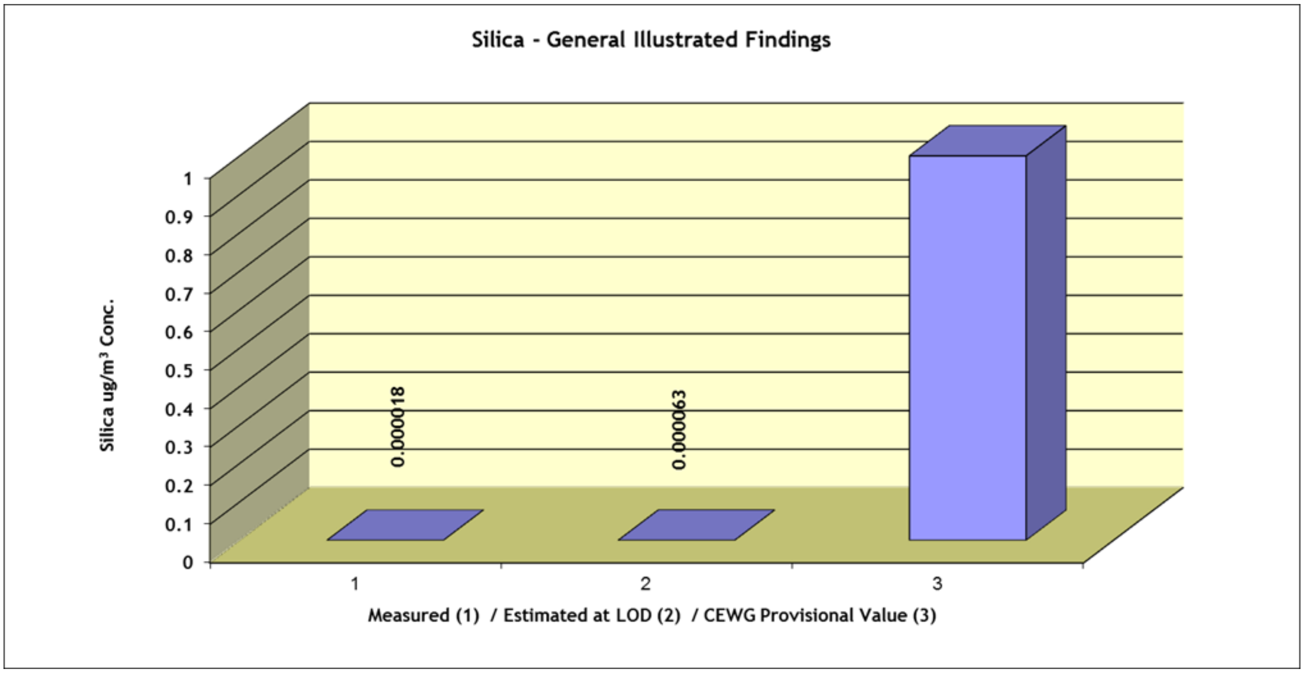

Silica - General Illustrated Findings
Silica ug/m³ Conc.
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.000018
0.000063
1
2
3
Measured (1) / Estimated at LOD (2) / CEWG Provisional Value (3)

Figure 2

2.0 Background

The Intel plant at which this testing occurred is located in Rio Rancho, New Mexico, adjacent to the Village of Corrales and near Albuquerque. The potential to emit crystalline silica from the VOC control systems (thermal oxidizers) at this plant has concerned diverse interest groups from these areas and elsewhere, and the topic of increased discussion in the past years. The public concerns voiced to the ATSDR led that agency to recommend additional testing of crystalline silica from the stacks of the Munters and Durr thermal oxidizers at Intel (Public Health Consultation, Intel New Mexico Facility, Public Comment Release, Feb. 2, 2009, p. 42, Recommendations). The ATSDR suggested measuring crystalline silica collected (deposited) in the units. CEWG proposed testing for the presence of crystalline silica concentration in the emissions of the thermal oxidizers to determine if there was detectable levels of crystalline silica emitted as part of Intel's particulate matter, and if silica was found at quantifiable levels, to accurately quantify the silica concentration and relative mass in the emissions sources that could be used for further modeling studies to assess potential fence line concentrations of the material.

An initial test plan, or citizen protocol, was discussed and drafted by the CEWG in support of this proposed sampling effort. The proposed program was discussed by the CEWG, STTF and its consultants, ERM, ATSDR, and NIOSH.[3] All of these groups were very active in the design of the process. ERM, ATSDR, and NIOSH were in communication and agreement in the type of filter media and NIOSH analytical methods.

An initial test plan or citizens protocol was discussed and drafted by CEWG and Intel in support of this proposed sampling effort. The proposed program was discussed between ERM, ATSDR, and NIOSH in defining an appropriate sampling method that would meet the objectives of the CEWG draft plan, with communication and agreement on the type of filter media, and duration of sampling in support of the silica assessment.

The field program was conducted by ERM, with direct interaction with CEWG in observing the execution of the sampling, recovery and packaging of the samples, completing the chain-of-custody forms, and observing daily sample shipments to the NIOSH approved third party laboratory to express mailing drop-offs.

Once laboratory data has been compiled by NIOSH, the lab data and supporting documentation is to be disseminated through appropriate representatives of CEWG, whom will incorporate the lab data with the source test information, provided herein, and conduct an independent and/or

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[3] (NIOSH is described in Wikipedia in part as follows: "The National Institute for Occupational Safety and Health (or NIOSH) is the United States federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH is part of the Centers for Disease Control and Prevention (CDC) within the U.S. Department of Health and Human Services.... NIOSH is a professionally diverse organization with a staff of over 1,400 people representing a wide range of disciplines including epidemiology, medicine, industrial hygiene, safety, psychology, engineering, chemistry, and statistics. The director of NIOSH is John Howard.")

parallel calculation of PM/silica concentrations and emissions in support of the program assessment reporting.

Concerns have been voiced to Intel, in newspapers, in a published book,[4] to the N.M. Air Quality Bureau, to the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), and repeatedly at public meetings of the Community Environmental Working Group (CEWG). The public concerns voiced to the ATSDR led that agency to recommend more testing of crystalline silica from the stacks at Intel. The CEWG proposes testing the crystalline silica emissions from both the Durr and Munters thermal oxidizers.

The ATSDR suggested measuring crystalline silica collected (deposited) in the units. The CEWG proposal differs slightly from this suggestion. The CEWG proposes measuring crystalline silica concentrations in the emissions to: 1) determine if there are detectable concentrations of crystalline silica emitted as part of Intel's particulate matter and 2) ascertain if further size distribution measurements of any crystalline silica are required to understand the possible health consequences of the emissions. The sampling and testing documented herein address specifically whether or not crystalline silica is present and emitted from the RCTO stacks at a provisional significant level adopted by the CEWG as $1 \mu g/m^3$ annual average at the Intel fence line.[5] The original questions posed by the ATSDR Follow up Committee are below and the entire documentation including answers to the questions are included in Appendix C.

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[4] "Boiling Frogs: Intel vs. The Village," by Barbara Rockwell, iUniverse, Inc., 2009, chapter "The First Body Down the River." pp. 199-203

[5] The reference used for the provisional "safe level" is: U.S. Environmental Protection Agency, "Ambient Levels and Non-Cancer Health Effects of Inhaled Crystalline and Amorphous Silica: Health Issue Assessment," EPA/600/R-95/115, November 1996, pp 5-17 through 5-21 and Appendix B-6.

3.0 Planning, Sampling, Testing, and Analysis Overview

3.1 Planning

Innovative Process of Community Involvement. The crystalline silica testing project was planned and carried out using an unusual community-centered process and uncommon resources. Distinctive features of the process, taken together, create a model for fresh approaches to environmental issues in communities generally. Unique features of community participation include:

1. The testing project was planned by a specially-formed, self-governing community committee -- the Silica Testing Task Force.

   - The STTF had six members: two non-Intel members of the CEWG, one Intel member of the CEWG, and three task force members nominated by Mayor Phil Gasteyer of the Village of Corrales. Two of the mayor's nominees are currently elected village councilors and the third was elected to be chair of the STTF by its members.

   - All aspects of the project were planned by the STTF in open public meetings. Minutes of the meetings are available.

2. The sampling of stacks at Intel was witnessed by eight community volunteers.

   - Three of the volunteers were the mayor's nominees on the STTF.

   - Each volunteer, two at a time, worked one of the four sampling shifts -- two day shifts and two night shifts completed over four days. The Intel STTF member attended all four sampling events.

3. The sample testing was done by a subcontracted analytical laboratory (Bureau Veritas) of the National Institute for Occupational Safety and Health (NIOSH), affiliated with the U.S. Centers for Disease Control and Prevention. Access to this non-commercial national testing resource was extremely valuable and greatly appreciated.

   - The test results were sent only to the chair of the STTF. Intel did not see the results before the community did.

4. The specific computations that tell the meaning of the test results in context with local air quality were established and agreed on before the sampling began.

   - A strict, provisional level of crystalline silica was established to guide further work. “Strict” means having a large margin of safety compared to existing standards in the nation and other states and the latest knowledge base for effects of silica. “Provisional” means the CEWG work to follow depends on whether test results are lower, higher or much higher than the provisional level.

- The specific computations, provisional level, and follow-up actions were laid out at a community meeting and remained subject to scrutiny and revision for six months before sampling began.
- The project found that planned actions and follow-up are easier to agree on before the test results are known.

All together, this array of procedures and resources represents a fresh approach to a long-standing community concern. The procedures were designed in public to deal with specific doubts about Intel's prior testing routine, as well as to utilize the unique history of the community itself.

3.2 Sampling Overview

The primary focus of the sampling program was to support testing of crystalline silica from the stacks of the Munters and Durr thermal oxidizers at the Intel facility. As there are no direct prescribed methods for silica sampling from stationary sources, a sampling approach was designed and executed that supported the proper methods for sample collection, sampling handling, and sample analyses to meet the program objectives. The program was designed around the quantitative and representative collection of particulate from all the site's thermal oxidizer exhaust stacks with appropriate handling and subsequent analyses for both total particulate and silica (a subset of the collected particulate) to assess the silica emissions from all the Intel facility thermal oxidizer systems.

As overall approach was to conduct particulate sampling and take the exposed filters from the qualified test runs and analyze the filters for total particulate with further analyses for presence of silica, it was important to insure that overall approach supported compatible methods, representative processes, and defensible results.

This required the collaborative effort of (1) designing the field method (for quantifying the TO exhaust characteristics) that was compatible with the analytical methods (for taking the collected samples and analyzing for silica); (2) defining the method requirements that would support sufficient sample collection, (3) developing a test schedule that would test all units concurrently (refer to previous planning discussion); (4) insure that the testing was unbiased, qualified, and representative of the expected total source emissions; (5) collect a minimum number of samples from the program to support statistical significance and meet the objectives of the program.

The basic approach for the measurement program was to establish, from each exhaust stack, the physical measurements of exhaust gas temperature (in Farenheit), velocity and volumetric flow rate as well as the concentration of particulate (and silica) for each sampling period (test run) based on the samples collected. These data and measurements were then used to determine the mass rate per unit time of particulate and silica from each exhaust and further used in supporting data to compare to the CEWG provisional level developed as part of the program approach.

Information regarding HMDS usage and production levels before, during, and after the test can be found in Appendix G. Observers were briefed on this information at a training session. This information was also given to those who asked on site.

The sampling approach supported in this document assists in further defining the methods, steps and process undertaken in developing this full program to support quantifying representative emissions from all the Intel facility's thermal oxidizer stacks. The design and development of this program was the result of a collaborative effort between the STTF, its consultants, and individuals with considerable experience and understanding of source testing, analytical methods, facility operations, and program management and coordination. The CEWG delegated the specifics of this work to the STTF. Both groups were very active in the design of the process. ERM, NIOSH, and ATSDR consultants confirmed the substrate compatibility with elevated stack temperature and NIOSH analytical methods. NIOSH tested and endorsed this procedure.

3.2.1 Sampling Approach

Defining measurement methods for silica for the program focused on a number of key issues. Most predominantly, the thermal oxidizer stacks to be tested were stationary source exhaust streams (stacks) of high flow and elevated temperature. Existing silica sampling methods are based on industrial hygiene and worker exposure assessments that support using sampling equipment and collection materials under ambient conditions.[6] The introduction of high flow, temperature and moisture, required a different approach to the sampling method, equipment, and technique to meet these challenging source conditions. Further, it was necessary to support a measurement approach that would yield a sample, on a suitable substrate (filter) that would allow direct analyses for silica, with minimal handling using approved analytical procedures.

As silica would be in the form of a solid, or particulate fraction in the exhaust stream of the thermal oxidizers, the measurement method selected was an approved stationary source sampling method for particulate, with additional focus of collecting particulate on a suitable filter media (e.g. NIOSH suitable substrate). This would insure that the method and approach not only be compatible with the source environment for collection, but the subsequent silica lab method, for analyses. By collecting the particulate mass on a compatible substrate, the presence and quantity of silica in the collected sample could be easily determined.

Two (2) primary approved stationary source sample methods for particulate collection are available. EPA Reference Method 5 (RM5) "Determination of Particulate Matter Emissions

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[6] U.S. Environmental Protection Agency, "Ambient Levels and Non-Cancer Health Effects of Inhaled Crystalline and Amorphous Silica: Health Issue Assessment," EPA/600/R-95/115, November 1996, p. 7-2.

from Stationary Sources," and EPA Reference Method 17 (RM17), "In-Stack Particulate." In RM5, 120ºC (248ºF) is established as a nominal reference temperature and in order to maintain this collection temperature the method employs a heated glass sample probe and a heated filter holder. Further, with this method, to quantitatively collect all particulate, the method results in two particulate fractions, one the exposed filter, and (2) the quantitative rinse of particulate that deposited along the extended length of the sample probe and filter holder (typically acetone is used as the rinse solvent).

RM17, employs the use of in-stack filtration where typically the filter holder is placed in-stack and the sample is directly impacted on a filter media contained within the filter holder (exposed to the gas effluent). Similar to RM5, the exhaust gas is drawn through the sampling system under a controlled sampling approach. In the RM17 approach, the PM concentrations (over the expected temperature range of the thermal oxidizer systems) is independent of temperature, and it was much more desirable to eliminate the glass probe and the heating systems, and to sample at stack temperature to provide a single sample that would be compatible with subsequent analyses.

EPA RM17 (in-stack) was chosen over EPA RM5 (1) to maximize the particulate collection on the filter media and not minimize the impact of the collected sample on the internal surfaces of the sample train prior to collection of PM on the filter, and (2) further to allow quantitative collection of PM at the elevated exhaust gas temperatures exhibited by the individual Munters thermal oxidizer stacks. A very basic illustration of the EPA RM17 sampling train is illustrated in Figure 1.

Once the most suitable particulate sampling method was selected, the focus was directed on identifying a compatible substrate to support the elevated source temperatures and meet the needs of the analytical methods for silica. The Durr exhaust stacks have the thermal oxidizer and fresh air exhaust from the concentrator wheel comingled into one stack that significantly reduces the exhaust temperature, minimizing sample system conflicts with elevated temperatures. However the Munters systems have separate wheel and thermal oxidizer exhausts that result in isolated TO stacks of lower flow but much higher temperatures. Previous exhaust measurements for these thermal units had demonstrated Munters TO stack temperatures in the 650ºF-670ºF range, while the comingled Durr exhaust stack temperatures were measured in the 120ºF-125ºF range.

As the focus of the program was to collect exhaust stack samples of particulate matter (PM) on a NIOSH approved substrate to allow subsequent silica analyses, care was taken in the final sample system design to insure that the elevated exhaust gas temperatures would not affect the integrity of the filter media used. The Munters elevated exhaust temperatures posed the greatest hurdle in the substrate selection for source method and analytical compatibility. The media selection was critical in insuring sample integrity for the subsequent silica analyses. Based on historical information and previous stack exhaust tests for similar source exhaust characteristics, Teflon™ (TFE) coated glass fiber filters had been used in the collection system. However, in detailed review, it was defined by the manufacturer that this media has an upper temperature tolerance of approximately 550ºF, that would be challenged in the Munters TO exhaust gas stream and was requested by NIOSH to investigate other media.

Review of other media type that had better temperature suitability (higher tolerance range) were found to have a significant "dirty" background (e.g. binders and weave), that would essentially blind silica analyzes due to the background. Therefore, to accommodate the use of the Teflon™ (TFE) coated glass fiber filter identified as an appropriate media for silica analyses based on it higher temperature tolerance and clean background, a review on modifying the method sample train was undertaken to support the use of the filter without affecting the integrity of the sampling system.

To accommodate these elevated Munters TO temperatures using the RM17 in-stack method, a modification was employed to ensure (1) the actual temperature at the filter surface was reduced to not affect the integrity of the TFE coating on the media; (2) the length of the nozzle and filter holder (with extension) was minimized to support quantitative collection of the solid PM fractions, (3) that the modified system was compatible with the physical limitations at the individual stack locations in relation to clearance of sample system(s) to outside obstructions, and (4) placement of the nozzle in the exhaust stream at the appropriate sample positions was achievable. Based on the acceptable temperature range of the comingled exhaust stacks for the Durr systems, nozzle extensions were not required and the in-stack sample approach followed that of EPA RM17 without modification to the sample system and configuration.

Moreover, this approach improves the ability to perform a complete quantitative recovery of particulate deposited in the components prior to the filter (sample nozzle and front half of filter holder). It was specifically requested by the NIOSH laboratory to have a filter (solid) sample only from the test runs to support the silica analyses and lab equipment compatibility.

A prescreen assessment was conducted on site using the modified sampling assembly that extended the sample nozzle from the filter holder. The extension was of sufficient length to reduce the temperature of the gas impacting the filter but have as short a length possible to eliminate deposition prior to the filter. With this configuration, two individual tests were conducted on site with the nozzle extension under a full system test mock-up of sampling at the appropriate extraction rate for a period of four (4) hours (target sample times for the full test series). The exposed filters were sent to NIOSH to confirm that the integrity of the filter was maintained, assess adequacy of the media for silica screening, and further ensure the target sample times and extraction rates did not overload the filters for the required analyses. Indication from NIOSH supported that the substrates were not compromised for the intended analyses nor the filter loadings were inadequate for the intended program objective.

3.2.2 Field Sampling Execution

With the method, equipment configuration, suitable substrate, sample volumes, and target analyses confirmed, the field program coordination was developed and scheduled. To support facility wide assessment of the potential total silica emissions from all five RCTO stacks (3-Munters and 2-Durr control systems), it was requested that the sampling be conducted simultaneously from each of the five units (exhaust stacks). This concurrent approach was supported to eliminate any concern of process shift between units by capturing emissions from all thermal abatement systems at the same time. Under this configuration five (5) independent sampling systems were setup and operated to support the concurrent testing at each of the five individual VOC abatement systems.

Further, to support the program objectives, testing was not conducted at the same period for each series. The testing was designed to support a series of two morning (~0800-1200) and two evening (~ midnight – 0400) test cycles for extended sample periods of 4 hours per test run for the five units over an entire operational week. Testing was supported at the beginning and end of a typical work week for a total of twenty (20) individual test runs.

Table 1 provides the testing chronology for the field program defining the dates of each test and associated start and stop times of the test runs. Field coordination between test teams was provided to attempt to support exact start and stop times for all runs.

Table 1
Field Program Testing Chronology

Date	S/S	Munters TO-1	Munters TO-2	Munters TO-3	DURR F11XB	DURR F11xF
12/07/10	START	08:17	08:17	08:19	08:15	08:15
	STOP	12:17	12:17	12:19	12:15	12:41
12/08/10	START	00:16	00:17	00:18	00:15	00:15
	STOP	04:16	04:17	04:18	04:15	04:15
12/09/10	START	09:06	09:07	09:08	09:05	09:05
	STOP	13:06	13:07	13:08	13:05	13:05
12/10/10	START	00:16	00:17	00:18	00:15	00:15
	STOP	04:16	04:17	04:18	04:15	04:15

As the Durr and Munters system and exhaust stacks had been subjected to prior emissions testing, adequate sample ports and platforms were already in place to support the extended sampling program at each exhaust (stack) location. All test locations were verified as representative sampling locations for flow rate and particulate measurements following EPA Reference Method 1 “Selection of Traverse Points”.

The field methods used were guided by EPA's Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods, and 40CFR60 Appendix A Reference Methods 1-4 and EPA RM17 (for in-stack PM), and modified where necessary to be directly compatible with the silica objectives of this program. The subsequent analyses of the exposed filters from the field measurements were supported by a third party NIOSH approved laboratory and the specifics of the analytical process is further detailed in Section 2.2.3 of this report. A list of the field primary methods applied in this program follows:

EPA RM1	"Selection of Traverse Points"
EPA RM2	"Determination of Duct Gas Velocity and Volumetric Flow Rate"
EPA RM4	"Determination of Moisture Content in Stack Gas"
EPA RM17	"Determination of Particulate Matter Emissions from Stationary Sources"

A brief description of the primary methods is provided below.

EPA Reference Method 1. This method is designed to aid in the representative measurement of pollutant emissions and/or total volumetric flow rate from a stationary source. A measurement site where the effluent stream is flowing in a known direction is selected, and the cross-section of the stack is divided into a number of equal areas. Traverse points are then located within each of these equal areas.

EPA Reference Method 2. This is conducted to determine the average gas velocity in a stack is determined from the gas density and from measurement of the average velocity head with a Type S (Stausscheibe or reverse type) pitot tube. The velocity measurement points were guided by EPA RM1 and ensured that a representative data set was obtained at the cross section of the measurement location. Concurrent with the measurement of velocity, pressure and gas temperature were also recorded. Gas temperatures were measured using a Type-K thermocouple attached to the Pitot, oriented in the same measurement plane as the velocity measurements. The Type-K thermocouple was connected to a calibrated digital pyrometer for documenting temperature. Data derived from the stack pressure and temperature records were used in the determination of the exhaust gas velocity and flow rate.

EPA Reference Method 4. The reference method is used for accurate determinations of moisture content from the stack gas and is used is support of correcting stack exhaust volumes and sampled gas volumes to standard conditions. The reference method is conducted simultaneously with a pollutant emission measurement test run, and in this case integrated into EPA Reference Method 17, the primary method used for particulate collection in this program.

EPA Reference Method 17. This method is applied for the determination of PM emissions, where PM concentrations are known to be independent of temperature over the normal range of temperatures characteristic of emissions from a specified source category. Following this method, PM is withdrawn isokinetically from the source stack and collected on a pre-weighed filter. The PM mass, which includes any material that condenses at or above the filtration (stack) temperature, is determined gravimetrically after the removal of uncombined water. All results are corrected to standard conditions as part of the normal calculations of the method. Concurrent with the PM sample collection, stack gas velocity and temperature were measured (as defined in EPA RM2) and the resultant stack flow rate measurements used to support reporting of the emissions by combining the PM (or silica) concentration and exhaust gas flow rate.

EPA RM17 (in-stack) was chosen over EPA RM5 (Determination of Particulate Matter Emissions from Stationary Sources) to minimize the impact of the collected sample on the internal surfaces of the sample train prior to collection of PM on the filter, and further to allow quantitative collection of PM at the elevated exhaust gas temperatures exhibited by the individual Munters thermal oxidizer stacks. A very basic illustration of the EPA RM17 sampling train is illustrated in Figure 1.

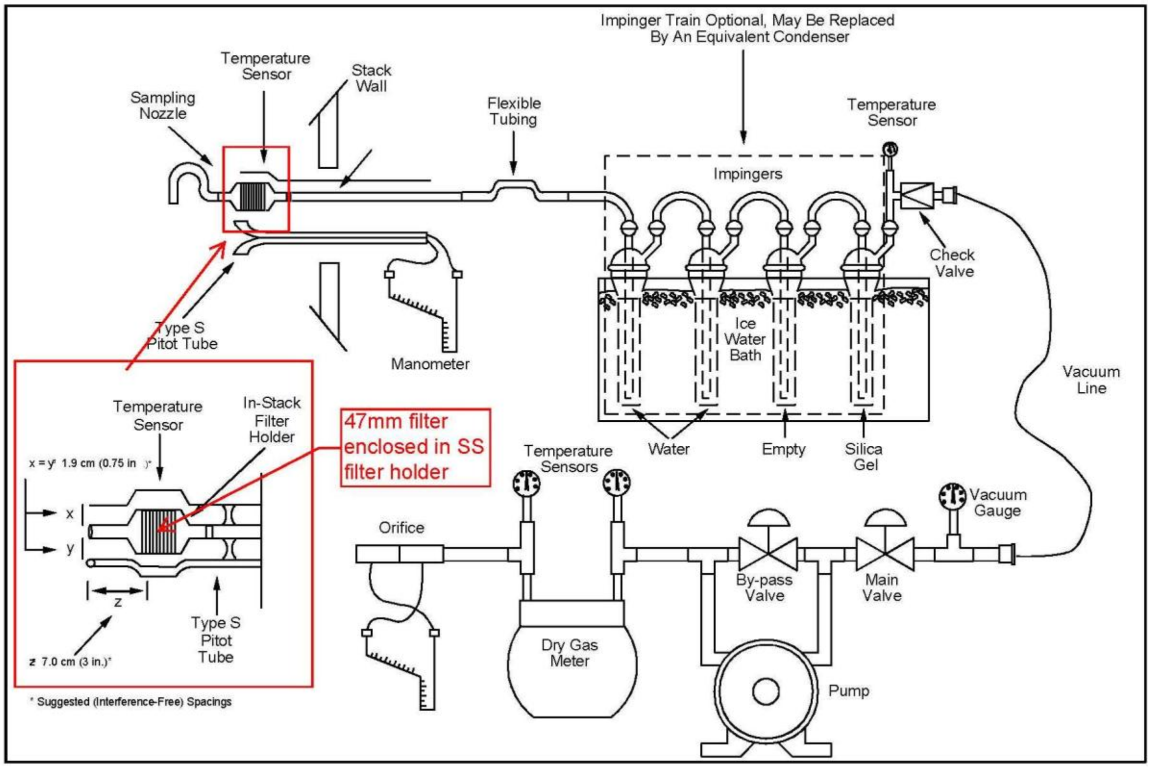

Figure 3 – EPA RM17 Sample Train

For this sampling application, a Teflon™ coated glass fiber filter was used in order to provide a media that was robust to support the elevated exhaust gas temperatures while providing a very low stable silica background for analysis.

In conducting the field measurements, initial velocity traverses were conducted at all stacks to initially align the selection of the appropriate sample nozzles with the measured exhaust gas parameters to support PM isokinetic sampling. Prior to the initiation of each test cycle (the five units are tested for each cycle), a full stack traverse was conducted to identify the probe and nozzle placement in each stack.

Once traverses were completed and sample points determined, the filter holder was loaded with a pre-numbered and pre-weighed TFE coated filter, the filter holder assembled into the complete sample system, and full system leak check completed. Once all sample systems were confirmed to meet the leak check acceptance criteria, the probes with filter holders were placed in-stack at the designated sample point, allowed to equilibrate, and sampling was executed.

Sampling was executed for four (4) hours for each test run. During the 4 hour test, at 19 minute intervals, the stack gas velocity and temperature were recorded along with the reading from the extractive gas meter (sample volume), the meter temperature, meter pressure, system extraction vacuum, and the temperature of the sample gas leaving the moisture train.

At the completion of the four hour test run, the sample pump was turned off, the probe removed from the stack, and a post leak check of the sampling system was initiated at the highest vacuum recorded during the test run. After test confirmations, the filter assemblies were detached from the sampling system and directed to the site trailer for filter recovery. During Run 1 at VOC-16-lt2-1s (11X-F Durr RCTO), the sampling was paused between 08:27 and 08:53 to replace a failed pump in the sampling system. The total sample run time was four hours and the sample volume unaffected.

Each filter holder (Figure 2) was taken apart, and the filter media removed from the filter holder and support screen and transferred to its prescribed numbered filter Petri slide holder. The front half of the filter holder support (nozzle, extension, and filter holder assembly), was carefully and thoroughly brushed to capture any loose material that may have adhered to the inside of the system components. This loose material was quantitatively transferred to the filter surface and slide holder, then capped, taped, and secured to eliminate sample loss.

Figure 4 - Filter Holder with Filter Support Screen

The recovered filter information was entered into the daily field chain of custody form documenting; (1) NIOSH filter ID, (2) Field sample ID, (3) Source location, (4) run #, (5) sample date, and (6) analytical requirements, and (7) any specific comments/remarks related to the specific sample and recovery process. Processed samples were placed in a shipping container with corresponding chain-of-custody, sealed and transferred to Federal Express for direct shipping to the NIOSH designated laboratory.

For filters Intel-7 (VOC-138-1-120-2s Run 2), Intel-10 (VOC-138-3-120-2s Run 2), and Intel-17 (VOC-138-3-120-2s Run 3) graphite fragments from outside of sample probe deposited onto the filter during recovery. These graphite fragments were left on the filter, and are assumed to potentially bias the particulate results high and have no effect on the silica analysis.

3.2.3 Laboratory Analyses

Laboratory analyses procedures in support of this program effort are provided in the following section. The narrative is taken directly from the 14 March 2011 "Analytical Results for Feasibility Study and Field Survey for Crystalline Silica" memorandum (*ATSDR.Intel.Sequence 11239.cover memo.pdf)* provided as part of the laboratory data submittal by NIOSH.

A collaborative project between CDC / NIOSH and ATSDR / DHAC was initiated September, 2010, in order to provide analytical support services for an ATSDR community health project. The issue of concern was the possible presence of crystalline silica in stack emissions at a production facility. The NIOSH industrial hygiene laboratory is housed within the Division of Applied Research and Technology (DART) with an associated contract laboratory for which DART provides direct oversight. Both the DART in house laboratory and the NIOSH contract laboratory (Bureau Veritas North America) are currently accredited via the American Industrial Hygiene Association (AIHA) accreditation program.

A formal request for analytical support services was submitted by the NIOSH / DART QA Manager to the NIOSH / DART Laboratory Coordinator, with a Laboratory Control Number assigned (Sequence 11239). This request is attached, *"ATSDR.Intel.Sequence 11239.pdf."* All information concerning this collaboration has been filed under Sequence 11239. All samples associated with this collaboration have been retained in the DART XRD laboratory which is a limited access (secured) laboratory. For the purposes of transparency, all reports attached are the actual Quality Assurance version of the reports, which include all information associated with the analyses, not just laboratory results. In addition, all XRD chromatograms are included.

All analyses were accomplished via X-ray diffraction (XRD) using NIOSH Manual of Analytical Methods (NMAM) 7500, "Silica, Crystalline, by XRD." NMAM 7500 can be downloaded from the NIOSH NMAM website, www.cdc.gov/niosh/docs/2003-154.

This collaboration was accomplished in two phases which are described below.

1. Feasibility study. *Laboratory Control Number, Sequence 11239-CA*. The field study involved stack sampling which needed to be performed via US EPA Reference Method (RM) 17, "Determination of Particulate Matter Emissions from Stationary Sources." The filters employed for the sampling were Emfab™ filters, 47-mm. Because these filters are borosilicate microfibers reinforced with woven glass cloth and bonded with PTFE, it was necessary to determine the feasibility of use for crystalline silica analysis. A protocol was developed for a feasibility study, which is included in the feasibility study report and described in the attachment,

"ATSDR.Intel.Sequence 11239- CA.QA protocol.feasibility study.pdf." The crystalline silica feasibility study included both quartz and cristobalite since cristobalite is a polymorph of crystalline silica which may be formed at high temperatures.

In order to ensure that the Emfab™ sampling filters would yield quantitative recovery of crystalline silica with no interferences from the filter material, a set of 20 blank filters were sent for a feasibility study. All blank filters were analyzed for possible XRD detection of crystalline silica. No crystalline silica XRD peaks were detected, indicating that the sampling filters would not be a source of interference in the field survey samples. The analytical report documenting the investigation of possible crystalline silica interferences is attached, *"ATSDR.Intel.Sequence 11239-CA.blank filter study.narrative and XRD chromatograms.pdf."*

The next step in the feasibility study was to determine if quantitative recovery could be obtained from direct-on-filter measurement of crystalline silica from the Emfab™ filters. Sample preparation / redeposition is not possible for Emfab™ filters, necessitating direct-on-filter measurement of crystalline silica. It was essential to investigate if the sampling constraints would affect the analytical results. Since the OSHA Permissible Exposure Limit (PEL) for quartz can be equated to 100 micrograms per filter for analytical purposes, a level close to this amount (120 micrograms) was deposited on 10 blank Emfab™ filters for quartz and 10 blank Emfab™ filters for cristobalite. The results showed quantitative recovery for both crystalline silica polymorphs, indicating the feasibility of using Emfab™ filters for sample collection and subsequent analysis via XRD. The narrative analytical report documenting the recovery studies for crystalline silica is the same as the attachment above. The XRD chromatograms for the recovery study are attached, with quartz documented on pages 10-59 and cristobalite documented on pages 66-96 of the attachment, *"ATSDR.Intel.11239-CA XRD charts.recovery.Emfab filters.pdf"*

The two sets of XRD chromatograms associated with the blank filter interference study and the crystalline silica recovery study are sent exactly as received from the laboratory, with no data manipulation. With the feasibility study completed, yielding results which indicated the suitability of use of Emfab™ sampling filters for possible presence of crystalline silica in the facility emissions stacks, the field study was cleared to proceed.

2. Field study. *Laboratory Control Numbers, Sequence 11239-CB (gravimetric) and 11239-CC (silica via XRD).*

A set of 40 blank Emfab™ filters were sent to the laboratory, where they were pre-weighed in preparation for the gravimetric study, via NMAM 0600, "Particulates, N.O.R., Respirable." For quality assurance purposes, 16 filters were retained at the laboratory for media blanks and 4 filters were designated as field blanks. The 20 field sample filters and 4 field blank filters were then Fed-Exed directly from the laboratory to the survey site prior to the sampling dates of December 6-10, 2010.

Upon completion of the sampling, the filters were submitted directly to the laboratory for analysis. The first analysis was for particulates (gravimetric). The analytical report is attached, *"ATSDR.Intel.11239-CB.gravimetric.pdf."* The results show high loadings of particulates on the filters[7]. Subsequent to the gravimetric analysis, the filters were analyzed for crystalline silica, quartz, cristobalite and tridymite. Since the samples were required to be measured direct-on-filter, with no sample preparation and no sample redeposition, accommodation for the XRD sample holder had to be made. Due to the fact that the XRD can only accept samples on 25-mm size samples, upon careful inspection of the sample filters for homogeneous distribution of particulates, it was decided to take a center punch from each sample for XRD analysis. The final results were extrapolated back to an effective sampling area based on the actual surface area of the filter exposed in the sampling stream.

Further details on this procedure are given in the attached narrative and data report, *"ATSDR.Intel.11239-CC.silica narrative and data.pdf."* It should be noted that the filters were heavily loaded with particulates, relative to ambient breathing samples, indicating sufficient sample to detect the presence of crystalline silica. All but one sample exhibited no XRD peaks for crystalline silica, yielding an ND (none detected) for these samples. One sample exhibited a large peak at the primary diffraction angle for quartz, Intel-10. Quartz was not confirmed since there was no secondary quartz peak detected. Quartz has a known ratio for the primary to secondary peak; the high intensity of the primary peak for this sample would have given rise to a substantial secondary peak had quartz been present. The client's paperwork noted that there were pieces of the graphite ferrules used in the equipment present on this sample. All XRD chromatograms for the field survey samples are attached, *"ATSDR.Intel.11239-CC.XRD chromatograms.pdf."*

Due to the fact that the sampling filters were borosilicate microfibers reinforced with woven glass cloth and bonded with PTFE, there was no sample preparation via NMAM 7500 (low temperature asher, muffle furnace, tetrahydrofuran) which would fully digest the sample for further analysis (amorphous silica). Therefore, only gravimetric and crystalline silica results are reported.

It should be noted that these data were reviewed by a NIOSH silica expert, the author of the 4th edition NMAM 7500, Rosa Key-Schwartz. In order to avoid any conflict of interest (the DART Quality Assurance Manager was also the silica expert), the entire set of reports was also reviewed in detail for QA purposes by a member of the DART Quality Assurance activity, Paula Fey O'Connor. The reports reflect this by the initials for sign-off on each of the 3 Sequences at the top right of the cover pages, "PFO for RK-S." The entire set of reports was also reviewed by the NIOSH Laboratory Coordinator, Charles Neumeister, reflected by the initials for sign-off, "CEN."

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[7] Filter loading reference is based on typical ambient filters and not that of filters exposed for particulate emission testing purposes from stationary sources.

3.2.4 Quality Assurance / Quality Control Activities

Verification of the proper operation of the field equipment and instrumentation was performed prior to the field sampling effort, supported by on site verifications of extractive meters and pumps, followed by post test calibration checks, specifically with gas sampling consoles. Calibrations were performed as described in the EPA publications "Quality Assurance Handbook for Air Pollution Measurement Systems; Volume III - Stationary Source Specific Methods" (EPA-600/4-77-027b) and EPA 40 CFR Part 60 Appendix A. QC measures were used to ensure the generation of reliable data from sampling activities. Proper collection and organization of source information followed by clear and concise reporting of the data was the primary goal in the project. The data input from the field data to the computer spreadsheets were cross-checked to ensure that the data has been transferred accurately.

All data is reported in standard units, where applicable, depending on the measurement and the ultimate use of the data. Field spreadsheets and summary data (provided Appendix F-1) will be used with the completed laboratory data to support reporting PM and silica concentrations and emissions.

Coupled with the source specific testing data, RCTO process data for all systems was continually documented to demonstrate appropriate operation by documenting thermal oxidizer chamber temperatures and desorb temperatures. These data are provided with the summary information and further provided in full in Appendix F-3 *RCTO Documented Process Data* of the report.

4.0 Discussion of Results

Table 2 provides results developed for the key measured or calculated parameters derived from each of the five (5) unit test series for the thermal oxidizer systems. Each column in the table represents the average stack parameters of the four individual runs for each abatement system test series. The discussion of results provided herein, as well as the field documentation provided in the Appendices of this report. Further detail of all recorded and calculated parameters for each separate test run of the individual system test series can be referenced from this data.

Data developed from the test series, coupled with the mass PM and silica data derived from a third party laboratory, supports the reporting basis of PM/silica concentration and emissions by individual test, by RCTO abatement unit and collectively for the facility.

Table 2
Results Summary of Source Test Series

Parameter / Source Series	Munters TO1 Series	Munters TO2 Series	Munters TO3 Series	Durr F11x-B Series	Durr F11X-F Series
Total Sampling Time (min)	240	240	240	240	240
Stack Temp (^{o}F)[8]	644.6	677.8	649	125	128.9
Gas Exhaust Velocity (FPS)	33.12	35.78	34.13	42.31	38.75
Exhaust Flow Rate (ACFM)	3,415	3,689	3,519	23,846	21,839
Exhaust Flow Rate (SCFM)	1,298	1,355	1,326	17,568	15,991
TO Oxidizer Avg. Temp (^{o}F)	1385	1384.9	1385	1369.9	1369.9
Desorb Avg. Temp (^{o}F)	359.8	360	360.2	350	349.9
PM Concentration (µg /m^{3})	880.84	703.69	823.7	744.86	79
PM Emissions (lbs/hr)	4.28E-03	3.58E-03	4.09E-03	4.89E-02	4.72E-03
Silica Concentration (µg /m^{3})	ND	ND	ND	ND	ND[1]
Silica Emissions (lbs/hr)	ND	ND	ND	ND	ND[1]

[1] Run #1 (Intel-3 substrate) supported a reported laboratory value of 310 µg quartz (within the analytical range). This mass value equates to 103.1 µg/m^{3} for the individual run. The remaining

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[8] Average sampling temperatures. The average "sampling temperatures" = average stack temperature at the sampling point are in the table ….values are represented in the second line in the table for each system…for each series the average value identified is drawn from the average of the 4 tests for each series in Tables 3, 4, 5, 6, and 7.

3 runs of the test series, for VOC-16-lt2-1s, were reported as non-detect (ND); refer to Table 5 for individual test runs and results)

Table 3 through Table 7 provides the detailed source data derived from each test run of the each control unit test series. These data were used is the development of PM/silica concentration and emission for each of the five (5) RCTO emission stacks supporting the combustion process. The purpose of this data is to report the results for each run of the test series (4 total runs for each test series) and provide comparative data for reviewing changes, variability, and consistency from test to test for each run series.

Table 3
Summary of Munters TO-1 (VOC138-1-120-2s) Test Series

Run Number		1	2	3	4	Average
Filter #		INTEL-1	INTEL-7	INTEL-15	INTEL-20	
Run Start Time		08:17	00:16	09:06	0:16	
Run Stop Time		12:17	04:16	13:06	04:16	
Average Stack Temp	(˚F)	645.6	646.1	641.9	644.7	
Standard Meter Volume	dscf	105.539	111.637	107.054	104.757	107.247
Average Stack Gas Velocity	ft/sec	32.77	33.99	32.80	32.91	33.12
Actual Stack Flow Rate	acfm	3,379	3,505	3,382	3,393	3,415
Dry Standard Stack Flow Rate	dscfm	1,279	1,334	1,287	1,293	1,298
Percent of Isokinetic Rate	%	100.4	100.4	99.9	98.9	99.9
Mass of Particulate	µg	3200	2900	2100	2500	2675
Stack PM Concentration	µg/dscf	30.32	25.98	19.62	23.86	24.94
Stack PM Concentration	µg/m^3	1070.76	917.37	692.74	842.77	880.84
Particulate Emission Rate	lbs/hr	5.13E-03	4.58E-03	3.34E-03	4.08E-03	4.28E-03
Mass of Silica	µg	ND	ND	ND	ND	ND
Stack Silica Concentration	µg/dscf	ND	ND	ND	ND	ND
Stack Silica Concentration	µg/m^3	ND	ND	ND	ND	ND
Silica Emission Rate	lbs/hr	ND	ND	ND	ND	ND

Table 4
Summary of Munters TO-2 (VOC138-2-120-2s) Test Series

Run Number		1	2	3	4	Average
Filter #		INTEL-2	INTEL-8	Intel-16	INTEL-MB1	
Run Start Time		08:17	00:17	09:07	08:17	
Run Stop Time		12:17	04:17	13:07	12:17	
Average Stack Temp	(˚F)	679.8	679.9	673.5	677.8	
Standard Meter Volume	dscf	107.973	111.065	109.635	107.938	109.152
Average Stack Gas Velocity	ft/sec	36.35	36.10	35.21	35.46	35.78
Actual Stack Flow Rate	acfm	3,748	3,722	3,630	3,656	3,689
Dry Standard Stack Flow Rate	dscfm	1,372	1,370	1,339	1,341	1,355
Percent of Isokinetic Rate	%	99.7	99.8	99.6	99.6	99.7
Mass of Particulate	µg	2700	2200	1900	1900	2175
Stack PM Concentration	µg/dscf	25.01	19.81	17.33	17.60	19.94
Stack PM Concentration	$\mu g/m^3$	883.09	699.52	612.01	621.63	703.69
Particulate Emission Rate	lbs/hr	4.54E-03	3.59E-03	3.07E-03	3.12E-03	3.58E-03
Mass of Silica	µg	ND	ND	ND	ND	ND
Stack Silica Concentration	µg/dscf	ND	ND	ND	ND	ND
Stack Silica Concentration	$\mu g/m^3$	ND	ND	ND	ND	ND
Silica Emission Rate	lbs/hr	ND	ND	ND	ND	ND

Table 5
Summary of Munters TO-3 (VOC138-3-120-2s) Test Series

Run Number		1	2	3	4	Average
Filter #		INTEL-3	intel-10	Intel-17	INTEL-MB-2	
Run Start Time		08:19	00:18	09:08	08:18	
Run Stop Time		12:19	04:18	13:08	12:18	
Average Stack Temp	(°F)	651.9	649.5	647.4	646.9	
Standard Meter Volume	dscf	106.202	108.278	107.78	110.761	108.255
Average Stack Gas Velocity	ft/sec	33.72	34.31	34.15	34.33	34.13
Actual Stack Flow Rate	acfm	3,477	3,538	3,521	3,540	3,519
Dry Standard Stack Flow Rate	dscfm	1,306	1,337	1,329	1,332	1,326
Percent of Isokinetic Rate	%	99.5	99.6	99.4	99.7	99.5
Mass of Particulate	µg	2,800	2,800	2,100	2,400	2,525
Stack PM Concentration	µg/dscf	26.36	25.86	19.48	21.67	23.34
Stack PM Concentration	µg/m^3	931.07	913.22	688.07	765.21	823.7
Particulate Emission Rate	lbs/hr	4.55E-03	4.57E-03	3.42E-03	3.82E-03	4.09E-03
Mass of Silica	µg	310	ND	ND	ND	-
Stack Silica Concentration	µg/dscf	2.9	ND	ND	ND	-
Stack Silica Concentration	µg/m^3	103.1	ND	ND	ND	-
Silica Emission Rate	lbs/hr	5.04E-04	ND	ND	ND	-

Table 6
Summary of DURR F11x-(VOC-np2-1s) Bridge Test Series

Run Number		1	2	3	4	Average
Filter #		Intel-5	INTEL-11	Intel-14	INTEL-19	
Run Start Time		08:15	00:15	09:05	00:15	
Run Stop Time		12:15	04:15	13:05	04:15	
Average Stack Temp	(˚F)	123.9	123.8	125.1	127.3	
Standard Meter Volume	dscf	109.158	114.043	110.849	111.614	111.416
Average Stack Gas Velocity	ft/sec	42.75	42.99	42.28	41.21	42.31
Actual Stack Flow Rate	acfm	24,096	24,229	23,831	23,229	23,846
Dry Standard Stack Flow Rate	dscfm	17,758	17,960	17,559	16,992	17,568
Percent of Isokinetic Rate	%	98.6	100.4	99.8	99.8	99.6
Mass of Particulate	µg	1500	2800	2800	2300	2350
Stack PM Concentration	µg/dscf	13.74	24.55	25.26	20.61	21.04
Stack PM Concentration	µg/m^3	485.28	867.05	892.03	727.72	744.86
Particulate Emission Rate	lbs/hr	3.23E-02	5.83E-02	5.87E-02	4.63E-02	4.89E-02
Mass of Silica	µg	ND	ND	ND	ND	ND
Stack Silica Concentration	µg/dscf	ND	ND	ND	ND	ND
Stack Silica Concentration	µg/m^3	ND	ND	ND	ND	ND
Silica Emission Rate	lbs/hr	ND	ND	ND	ND	ND

Table 7
Summary of DURR F11x-Fab (VOC-16-lt2-1s) Test Series

Run Number		1	2	3	4	Average
Filter #		Intel-6	Intel-12	Intel-13	INTEL-18	
Run Start Time		08:15	00:15	09:05	00:15	
Run Stop Time		12:41	04:15	13:05	04:15	
Average Stack Temp	(°F)	128.8	122.1	130.4	134.3	
Standard Meter Volume	dscf	102.273	154.717	150.433	151.387	139.702
Average Stack Gas Velocity	ft/sec	38.66	39.27	38.67	38.39	38.75
Actual Stack Flow Rate	acfm	21,787	22,133	21,796	21,639	21,839
Dry Standard Stack Flow Rate	dscfm	15,938	16,434	15,932	15,658	15,991
Percent of Isokinetic Rate	%	90.8	100.9	99.4	100.6	97.9
Mass of Particulate	µg	220	350	320	360	313
Stack PM Concentration	µg/dscf	2.15	2.26	2.13	2.38	2.23
Stack PM Concentration	µg/m^3	75.97	79.89	75.12	83.98	79.00
Particulate Emission Rate	lbs/hr	4.54E-03	4.92E-03	4.48E-03	4.93E-03	4.72E-03
Mass of Silica	µg	ND	ND	ND	ND	ND
Stack Silica Concentration	µg/dscf	ND	ND	ND	ND	ND
Stack Silica Concentration	µg/m^3	ND	ND	ND	ND	ND
Silica Emission Rate	lbs/hr	ND	ND	ND	ND	ND

Stack sampling of RCTO stacks at Intel's Rio Rancho, New Mexico site was performed to show whether or not the interaction of hexamethyldisilazane (HMDS) with the RCTO treatment process would form crystalline silica above the provisional levels promulgated by the CEWG. The data collected and discussed in this report answer several key questions: (1) what was the volume of gases that passed through the collection filters for the Durr and Munters stacks, (2) what quantities of crystalline silica were found on the filters from the Durr and Munters stacks and (3) is the quantity of the crystalline silica at or above the CEWG's proposed provisional level, 1µg/m^3 annual average concentration. Discussion and derivation of the provisional level is provided in Appendix K-5.

The sampling was conducted by Intel's consultant ERM. The sampling was witnessed by Intel employees and selected citizens from the community. Everyone who volunteered to observe was accepted by the STTF. A log of these individuals is presented in Appendix E. The data derived during collection is summarized in Table 2 through Table 7. The methods and overview of the sampling procedures have provided in Section 2.2 with further detail of the method provided in Appendix K-5.

The exposed field samples were submitted to NIOSH to determine particulate mass gain and analyze for the presence of crystalline silica. The NIOSH analytical approach involved center-punching a 25.4 mm section from the individual 47 mm diameter filter, to support direct compatibility with the substrate holder of the XRD analytical unit, and therefore, only a portion of the filter was actually analyzed. With the effective collection diameter reduced to 40 mm based on the placement of the Teflon "O-ring" in the supporting filter holder, the exposed filter surface was reduced. The XRD analyses for this test application were based on the assumed even distribution of material across the filter. Therefore the final results reported for the silica analyses were proportioned from the analyzed 25.4 mm filter size to that of the 40 mm exposed filter actual size. The post-gravimetric analysis of the filter substrates, for determination of the total mass PM gain, was conducted before the center-push process and XRD analyses.

Only one filter, Intel 3, had any measured crystalline silica. A second exposed filter provided material that indicated a large peak at the primary diffraction angle for the quartz (a crystalline form of silica) but could not be confirmed as there was no secondary peak (which, given the level of the primary peak should have been visible) and consequently was not quartz. This filter, Intel 10 (TO-3, Run #2), was addressed by assigning it as a non-detect, but setting the level of detection to 300 micrograms instead of a level of detection of 50 micrograms as used for the other filters. This filter was one in which the sampling notes indicated that there were pieces of graphite carried over on the filter from the field recovery. It was also one of three filters that NIOSH investigators reported loose material visible on the filter. For Intel 3, 310 micrograms of quartz were reported (Allen Schinsky, Bureau Veritas –ATSDR.Intel.11239-CC.narrativeanddata.pdf).

The primary question is: was there enough measured crystalline silica collected in the sampling to produce levels at the fence line above the CEWG provisional level (Appendix K-5 describes the basis for the provisional level). To take a very conservative approach to the question by using the highest estimate consistent with the measurement, one assumes that all samples are treated as detectable at the limit of detection (LOD); therefore, ten of the twelve Munters samples are assigned a quartz level of 50 micrograms, one is assigned a level of 300 micrograms and one at the reported measured level of 310 micrograms. Under this assumption, the average mass collected for the Munters test series was 92.5 micrograms for the twelve samples.

The modeling was done for the proposed Munters stacks in the context of the selection of the appropriate stack height to use for the new Munters units. This modeling did not address the Durr units and we don't have an appropriate dilution factor for the Durrs stacks. Accordingly, we estimate the fence-line concentrations from the Munters units alone and compare them to the CEWG provisional level. Other particulate modeling did not break out the RCTO stacks separately and thus, is not appropriate for the estimation of concentrations associated with the RCTO stacks that are the potential sources of crystalline silica.

The most accurate analysis of the Durr data required different modeling of dispersion from the Durr stacks, which have different flows and temperatures from the Munters stacks. Extra, detailed modeling for the Durr units was not justified in light of the very small, if any, level of crystalline silica detected in any stack, compared with what corresponds to the CEWG provisional level. In addition, all the Durr units are being replaced with Munters units.

A more approximate analysis of the Durr data indicates the highest possible emissions from the Durr stacks consistent with the measurements would be about five times higher than the highest possible emissions from the Munters. The fence line concentrations would scale approximately with the emissions, so that the estimated level would be about one three thousandth of the CEWG provisional level. The lowest level consistent with the measurements would be zero. The analysis for the Durr units is more sensitive to the level of detection, because the flows through the stacks are much greater and there were no measurements above the level of detection.

Particulate modeling done for RCTO stacks supported that an estimated emissions of one pound per hour (1 lb/hr) would produce concentrations of about 1 microgram per cubic meter outside the plant boundary on an annual average. This would correspond to a dilution of the stack gases by 178,000 parts of background air for every part of stack gas. The dilution factor was based on the actual stack gas flows which is the area of the stack times the stack gas velocity.

The average volume of gases that passed through the filter through one four-hour sampling period was 289 cubic feet under actual conditions. Note that the flow through the filters is described in tables 3, 4, and 5 in terms of standard meter volume expressed in dry standard cubic feet. In order to be consistent with the modeling procedure we must convert standard flows to actual flows. Tables 3, 4, and 5 describe the average actual stack flows and the dry standard stack flows. On average the actual flows are 2.68 times the dry standard stack flows, because the stack gases are at a much higher temperature and lower pressure than those of standard conditions. We found that the average standard meter volume was 108 standard cubic feet. Consequently, the actual volume of gases passing through the filter in cubic feet is:

$$V_{ft^3} = 2.68x108sft^3 = 289\,ft^3.$$

The actual flow in cubic meters is:

$$V_{m^3} = \frac{V_{ft^3}}{35.3\,ft^3/m^3} = 8.19m^3.$$

The sampled gas concentration is:

$$\chi_{sampled} = \frac{92.5 micrograms}{8.19 m^3} = 11.29 micrograms / m^3 .$$

After dilution from the stack, based on modeling, the concentration outside the boundary will be:

$$\chi_{outside} = \frac{\chi_{sampled}}{178000} = 0.0000634 micrograms / m^3 .$$

The answer is clearly “NO” since even assumptions based on the highest estimate of emissions consistent with the data produce concentrations about one fifteen thousandth of the CEWG provisional level of 1 microgram per cubic meter outside the plant boundary.

If we were less conservative and treated all the non detects as zero; 310 micrograms averaged with eleven zeros gives 25.8 micrograms per average Munters filter which corresponds to 0.0000177 micrograms per cubic meter, or 56000 times less than the CEWG level.

Since the analysis procedure is a little out of the ordinary, we might want to examine if errors in the procedure could change the primary conclusion that the crystalline silica concentrations will not exceed the CEWG provisional level.

An extreme assumption is that all of the particulate matter collected on the filter was actually crystalline silica. The material on the filters was weighed using standard techniques and the average weight on the Munters stack filters was 2333 micrograms (Allen Schinsky – Bureau Veritas ATSDR.Intel.11239-CB.gravimetric.pdf); and average sample volume 289 acf (8.19 m^3) for the same Munters tests (summary tables 2-7). The average does not include filters Intel 3, Intel 7, and Intel 10 where investigators observed “an uneven distribution of visible loose particulate matter present on the filter surface.” In this case we estimate at-the-fence concentrations of 0.0016 micrograms per cubic meter, one six hundred twenty-fifth (1/625) of the CEWG level. Consequently, we conclude based on the extreme assumption case, that there wouldn't be enough silica emitted by the Munters stacks to produce at-the-fence concentrations anywhere near the CEWG provisional level even if all the particulates were silica in the crystalline form.

We should also note that EPA investigators estimate crystalline silica levels in major metropolitan areas average about 3 micrograms per cubic meter, and they may be significantly higher in agricultural areas.[9]

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[9] (U.S. Environmental Protection Agency, "Ambient Levels and Non-Cancer Health Effects of Inhaled Crystalline and Amorphous Silica: Health Issue Assessment," EPA/600/R-95/115, November 1996, pp. 3-30.

5.0 Conclusions

The field results of the facility wide PM/silica emissions assessments, developed through concurrent testing of all five thermal control systems at the Intel Rio Rancho facility, are provided in this report document. The assessment program was successfully completed over a four day period during the week of December 07, 2010 testing each of the five emission units four (4) separate times. The twenty (20) qualified exposed filter substrate samples collected were sent via controlled chain-of-custody to a NIOSH directed laboratory that supported the analyses of total particulate (PM) and silica. The data developed from the third party analyses was used with the qualified field measurement data in defining the emissions from the VOC abatement systems, individually and collectively.

From the field assessment PM emissions from all RCTO exhausts were determined to be 0.066 lbs/hr. Individual source emissions for each test series ranged from 0.0046 lbs/hr for Munters-2 exhaust to 0.0489 lbs/hr for the Fab 11X Bridge site Durr system (VOC-np2-1s). PM emissions for each run series average, for each RCTO exhaust, can be compared directly to the facility permitted PM limits of 1.0 lbs/hr.

Based on the laboratory results of the exposed filters collected from the entire field test series, 19 of the 20 exposed filters were found to be non-detect (ND) for silica. The initial run of the first test series from the Munters TO-3 (VOC138-3-120-2s) resulted in the detection of quartz within the stated analytical limit of quantification (LOQ) of the analyses. Crystalline silica concentration and emissions for this test run resulted in a calculated value of 103.1 µg/m3 or 5.04E-04 (0.00050) lbs/hr, respectively. Crystalline silica source emissions are not regulated under federal, state or local limitations or site specific permit limits.

In support of the program to assist in further assessing silica concentrations, the sampling program was carried out using standard stack sampling techniques to collect filter samples from Intel RTO stacks. However, because the sampled gas temperatures from the Munters TO stacks were too high to permit the use of the filters normally used for samples for XRD analysis of crystalline silica, a modified system was developed collectively by ERM, ATSDR, and NIOSH crystalline silica expert Rosa Key-Schwartz to allow compatible source methods and compatible substrates required for silica assessment. The stack sampling was carried out using developed sampling techniques and measurements were closely observed by citizen observers. All five stacks were sampled simultaneously four times to include representative portions of the day throughout a typical operational week at the facility.

The collected filters were sent to NIOSH with careful chain of custody procedures. Measureable particulate matter was found on all exposed substrates and only one of these samples was positive for crystalline silica. The calculated crystalline silica concentration for this one sample was far below the CEWG provisional level.

Even the highest estimates of the crystalline silica consistent with the data were very low. As a further check, we estimated of at-the-fence concentrations, based on the assumption that all particulate matter collected on the filters consisted of crystalline silica with the use of previously developed dispersion models (AERMOD) and again found exposure levels well below the CEWG provisional level.

Maps