NJCAT TECHNOLOGY VERIFICATION

INFICON SCENTOGRAPH CMS200/CMS500

WITH SITUPROBE

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1.0 Introduction

1.1 NJCAT Program

NJCAT is a not-for-profit corporation to promote in New Jersey the retention and growth of technology based businesses in emerging fields such as environmental and energy technologies. NJCAT provides innovators with the regulatory, commercial, technological and financial assistance required to bring their ideas to market successfully. Specifically, NJCAT functions to:

Advance policy strategies and regulatory mechanisms to promote technology commercialization,
Identify, evaluate and recommend specific technologies for which the regulatory and commercialization process should be facilitated,
Facilitate funding and commercial relationships/alliances to bring new technologies to market and new business to the state, and
Assist in the identification of markets and applications for commercialized technologies.

The technology verification program specifically encourages collaboration between vendors and users of technology. Through this program, teams of academic and business professionals are formed to implement a comprehensive evaluation of vendor specific performance claims. Thus, vendors have the competitive edge of an independent third party confirmation of claims.

NJCAT has developed and published Technical Guidance Documents containing a technology verification protocol that is consistent with the New Jersey Department of Environmental Protection (NJDEP) Technical Manual and the Interstate Technology and Regulatory Cooperation (ITRC) program technical and regulatory documents. This technology verification review is consistent with the NJCAT general verification protocol contained in the guidance documents.

Pursuant to N.J.S.A 13:1D-134 *et seq.* (Energy and Environmental Technology Verification Program) NJDEP and NJCAT have established a Performance Partnership Agreement (PPA) whereby NJCAT performs the technology verification review and NJDEP certifies the net beneficial environmental effect of the technology. In addition, NJDEP/NJCAT work in conjunction to develop expedited or more efficient timeframes for verified/certified technology.

The PPA also requires that:

- The NJDEP shall enter in reciprocal environmental technology agreements concerning the evaluation and verification protocols with the United States Environmental Protection Agency, other local required or national environmental agencies, entities or groups in other states and New Jersey for the purpose of

encouraging and permitting the reciprocal acceptance of technology data and information concerning the evaluation and verification of energy and environmental technologies; and

- The NJDEP shall work closely with the State Treasurer to include in State bid specifications, as deemed appropriate by the State Treasurer, any technology verified under the energy and environmental technology verification program.

1.2 Technology Verification Report

On October 9, 2002, Sentex Systems, Inc. (now known as Inficon), 373 Route 46 West, Fairfield, NJ, submitted a Limited Preliminary Application for participation in the NJCAT Technology Verification Program. The technology offers an on-line, real-time approach for measuring volatile organic compounds (VOC's) in water, making use of a probe, trap, gas chromatograph and computer. The application request, after pre-screening by NJCAT staff personnel (in accordance with the technology assessment guidelines), was accepted into the verification program. This verification report covers the evaluation based on the performance claim of Inficon. (see Section 4.) Several meetings and interviews were held with the vendor and a number of telephone discussions and email exchanges were conducted to solicit relevant review materials and to refine the specific claim. The evaluation is based on third party reports, provided by Inficon.

1.3 Technology Description

1.3.1 Technology Status

Volatile Organic Compounds (VOC's) are among the most commonly found contaminants in water. These compounds, both in chlorinated and non-chlorinated forms, are used as solvents in industrial processes, or petroleum products from spills or leaks, and a number of them are suspected carcinogens or mutagens (Ref. 1). Because of this, VOC's are highly regulated in water under environmental protection programs by the federal, state and local governments. Their laws and regulations have imposed strict standards for drinking water, groundwater and facility waste effluent discharges. The United States Environmental Protection Agency (USEPA) regulates them under the Safe Drinking Water Act (SDWA), Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA) and several other federal acts. Many states regulate them under similar laws.

In order to comply with these laws, industrial and municipal facilities and their consultants need to conduct extensive VOC testing at many defined sampling locations at intake waters, in groundwater wells, on in-plant systems and at effluent discharge points. It is often necessary for ambient waters to be tested as well. This testing is needed to demonstrate compliance, whether it be of their process water being discharged into the environment or the drinking water product they provide to customers. To assure that they are in compliance, facility managers and consultants often have to be able to know the VOC levels and movement in their water streams at any given time so they can effectively operate their VOC treatment systems. Such testing suggests the need for an economical, quick and accurate method for measuring VOC's.

The traditional and basically only available process for VOC measurement has been to take the water samples (using a number of techniques and special containers in order not to lose the VOC's), preserve the samples and transport them to a fixed-base laboratory for VOC analysis. The time to get back test results is usually several weeks. At that time the results reflected what the VOC concentrations in the water were at the time of sampling. The laboratory results were probably accurate if the standardized methods were used but the results were very untimely and not representative of the present conditions. Although they may have satisfied the letter of the law and produced a data point for compliance purposes, this process was useless to any operator who was trying to understand present VOC levels and make immediate decisions about control or removal steps. Also, because regulators saw the traditional process as best available practice they found it difficult to require more aggressive VOC profiling and monitoring of waters. This is true not only because of the time-delay issue, but also the analytical cost. At present, a commercial laboratory VOC scan for one sample costs about $75.

The current interest for quick turn-around measurements of environmental contaminants, including VOC's in water is growing rapidly. This can be evidenced in two situations. The first is the national initiative to monitor waters, especially water supplies, sources and distribution systems, to provide early warnings of unintentional or intentional contamination. Chemical and biological terrorist monitoring networks are rapidly being established and have interest in using instruments and sensors that can provide real-time environmental information on any changes taking place in the monitored systems.

The second is the Triad approach for strategic assessment and characterization of environmentally contaminated sites including groundwaters. This approach, which makes use of field analytical measurements for real-time field decision-making, is being developed by the USEPA and greatly supported by the New Jersey Department of Environmental Protection. Triad is seen as a much faster, more cost-effective and better way of characterizing a site. Its underlying principle is that field decision-making can help direct sampling efforts better to get more representative samples and better, as well as quicker, understanding of site conditions.

Although the need has long been there for a real-time and accurate field VOC water monitoring technology, technology of this type has been slow in arriving into commercialization. This is partly because of the physical properties of VOC's which make them analytically very challenging. Their volatilities and varying water solubilities make them difficult to capture, preserve and hold in a water sample. They are also widely found in the environment and can easily cause analytical interferences and cross contamination problems. Under some conditions they can be degraded biologically and lost or transformed in the sample container. Most environmental measurements can be done in two sequential steps – sampling followed by analysis. VOC's, because of their physical nature, require a one step integrated sampling and analysis process. Such a process has not been generally available.

Although new technology for improved in-situ measurement methods (XRF, immunoassay and chemical test kits, etc.,) is being used for many of the other environmental contaminants of concern, improvement in VOC measurement technology has been slow and consequently VOC's are still monitored in the traditional way described above (Ref. 2). Some efforts have been made to bring VOC measurement on-site, but these have been limited to bringing out to the site an almost full-scale laboratory instrument in a mobile van. This has required a fully trained chemist using a laboratory type method and a low sample throughput rate of about one sample analysis per hour.

A number of years ago, Inficon who was at that time Sentex, realized that portable gas chromatography, being already applied to air monitoring, was also needed for water monitoring applications. This need included monitoring VOC's, not only at variable point locations with single analysis, but also for continuous monitoring applications. To respond to this, they expanded their portable gas chromatograph technology by combining it with a purge and trap technology This technology has been used to extract hydrocarbons from water. It is employed by many of the USEPA laboratory protocols for fixed-laboratory VOC testing.

This technology, which they brought to the market place, combines the sampling and analysis steps into a simple measurement system for analyzing VOC's in water streams. This technology is presently called the Scentograph CMS 200 with SituProbe or the Scentograph 500. The Scentograph 500 is the same system as the CMS 200, packaged in a protected, fixed location enclosure. (These are hereafter referred to in this report as the Inficon System.) The SituProbe is their sampling device. The company aims to provide a measurement system that can generate accurate, real-time, VOC in water measurements directly at or near the sampling point. An objective of this Inficon System is to help customers achieve considerable time and cost savings compared to taking samples and sending them off to a fixed-based commercial testing laboratory. More importantly, they wish to provide customers with their system a much better understanding of what the changeable VOC levels are at any given moment in the water system. This understanding can provide for better decision making in a number of different water monitoring and water treatment applications.

Inficon's success with their VOC technology builds on the company's years of experience in evolving a state of the art portable gas chromatograph (GC), which can provide the accuracy of a laboratory gas chromatograph. Their GC instrument has undergone innovative improvements in design, construction materials, carrier gas storage and detectors. It has been combined with a laptop computer that operates the instrument and provides access to a database. The portable chromatograph was developed to be rugged, easy to operate while maintaining almost all of the features of a laboratory gas chromatograph without the complications of a cumbersome laboratory operation.

The Company has integrated the portable gas chromatograph with a purge probe and trap device to accommodate single step VOC measurement. The earlier version of the Inficon System contained a probe which automatically drew a water sample up into a cell where the VOC's were purged into a trap. A laptop computer controlled the sampling cycle. The

current probe device, the SituProbe, further refines this by simply drawing the water through the flow-through cell, prior to purging of the VOC's into a trap. This novel enhancement allows for controlling flow through cycles which can allow for larger sample volumes and consequently higher concentrations of VOC's purged and trapped. This results in lower detection limits. Also, because there is no pumping action or mechanical disturbance to the sample, the Inficon System can handle oily or highly turbid samples, saving filtration costs and making VOC analysis routine where it might have been difficult or impossible to perform before.

Inficon offers wide flexibility in their GC set-up so that it can be adapted to specific industry requirements for VOC water measurement application. For example, using its unique Micro Argon Ionization Detector (MAID) detector, a user was able to detect methanol in pulp and paper processing water streams to support compliance with USEPA Cluster Rules. Another case was where water purveyors along the Ohio River were able to target and monitor specific VOC's in the river as an early warning of any threats on water supply source water.

Because of the uniqueness in portability, flexibility, adaptability, accuracy and speed, Inficon considers the Scentograph CMS 200 with Situprobe an innovative advancement in VOC water monitoring.

The Inficon System is considered relatively simple to operate and can be used on a day-to-day basis by a non-chemist. However, it does not completely eliminate the need for a well-trained chemist or technician. Supervision and training, as well as routine proficiency testing on quality control samples, as always is highly important.

1.3.2 Specific Applicability

The Scentograph CMS 200 with Situprobe has a potentially wide market for a number of VOC in water applications in the United States and globally. Because of the flexibility the Inficon System offers with the range of options in columns, detectors and operating conditions, the possible applications cover many areas of environmental monitoring. These applications can fall into two general categories. The first is where target analytes are known or anticipated and there is need for in-place, continuous, real-time data that is economical to generate. The other is where the Inficon System can be carried around and used strategically to gather quick, track-down type of data on a water system. In both cases there can be interest in a system that is fairly simple and easy to operate. These applications could certainly be in drinking water, industrial process water, wastewater, ambient waters in response situations and for groundwater remediation.

One of the main markets is for drinking water protection. Millions of people in the United States drink water from systems that are routinely out of compliance with federal Safe Drinking Water standards. The need for improved water infrastructure is a critical problem everywhere. This situation becomes even more acute with recent threats involving the potential for intentional contamination of our rivers, lakes and reservoirs. The fact is we cannot live, nor can industry function, without a continuing source of clean drinking water.

Dedicated VOC monitoring can be carried out on water sources, within drinking water plants, within distribution systems and on finished waters at the tap. All monitoring would be aimed at early warning and ultimately, good public health protection. Early warning monitoring could also detect heavy contamination loadings in advance, preventing disruptions to plant operations with their related financial consequences.

Industrial facilities could utilize this to help optimize VOC removals from process streams to support their pollution prevention and reduction programs. They could monitor to anticipate any unacceptable VOC levels that could escape from the plant in order to trigger appropriate countermeasures. Another use might be to collect self-monitoring data on their effluent discharges or in their ambient receiving waters.

The Inficon System's portability and capability to operate on batteries makes it possible to be carried around a shoreline or used on boats. The design allows the probe to be dropped to any water depth. With these advantages, the Inficon System offers great potential for use in investigatory or emergency response monitoring to track down a source of VOC pollution.

Inficon also foresees additional applicability in storm water monitoring, carbon bed breakthrough and monitoring of HRVOC's in cooling tower waters.

1.3.3 Range of Contaminants and Concentrations Measured

The Scentograph CMS 200 with SituProbe has been designed to measure VOC's in water. Depending on the way the Inficon System is set-up and the operating conditions chosen, it is conceptually possible to use it to measure any of the VOC's of common interest found in drinking waters, surface waters, water discharges, process waters and groundwaters. These are the specific VOC and halogenated VOC's identified in the prescribed drinking water (SDWA), surface water and pollutant discharge wastewater (CWA), and hazardous wastes (RCRA) method manuals as well as those published in the Federal Register. Similar methods exist in many state regulations.

The Inficon System can identify and effectively measure extremely low levels of VOCs (sub ppb's), which are normally undetectable by other methods. This is because of its ability to draw in larger volumes of sample and increase the concentrations of vapors captured, providing a sample enrichment factor greater than traditional purge and trap methods. Higher concentrations of VOCs in the parts-per-million (ppm) range may also be analyzed; however, sample dilution to obtain a concentration within the working range of the instrument may be necessary.

This technology is of particular value in cases where VOC's in water are known to exist but regulations are aimed at certain, "not to exceed levels." Unlike laboratory testing, the System can take a practical approach in focusing only in the action level range. This approach can allow for a more rapid response and often improved data quality.

1.4 Project Description

The purpose of this project is to verify the Inficon claim about the performance of the Scentograph CMS 200 with SituProbe stated in Section 4 of this report. The project entailed a number of meetings and discussions with the key contacts, review of performance information and data identified by the vendor, review of several EPA and other technical reports, review of several analytical methodologies, and web site searches for background information.

1.5 Key Contacts

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2.0 Evaluation of Applicant:

2.1 Corporate History

The original company was formed in 1980, under the name of Sentex Sensing Technology (initially under the name of Sinex Corp.), to manufacture analysis systems using gas chromatography, a well-established technology for an on-site analysis of vapors in air, water and soil and systems for the detection of vapors in explosives.

In 1984, the company became publicly traded under NASDAQ. In 1991 and later in 1996, the instrument division of the company was incorporated as a wholly owned subsidiary under the name of Sentex Systems, Inc. ("Sentex".) Dr. Amos Linenberg, the president of Sentex Sensing Technology also served as the president of the subsidiary. In 1998, the company was "taken private" by the firm's original founder, Dr. Amos Linenberg. The company grew in experience and activity, especially in explosives detection systems. Dr. Linenberg introduced the first known commercial explosives detection system to the world market.

In July of 2003, the assets of Sentex were acquired by Inficon, a company located in New York State. Inficon has been a leading developer, manufacturer and supplier of innovative vacuum instrumentation, critical sensor technologies process control software for the semiconductor and related industries and other industrial applications. Their analysis, measurement and control products are vital to original equipment manufacturers (OEMs) and end-users in the complex manufacturing of semiconductors, flat panel displays, magnetic and optical storage media and precision optics. Inficon also provides essential instrumentation for gas leak detection and toxic chemical analysis to the air conditioning/refrigeration, emergency response, security, and industrial hygiene markets. Headquartered in Syracuse, New York, Inficon has world-class manufacturing facilities in the United States and Europe and worldwide offices in the U.S., China, France, Germany, Japan, Korea, Liechtenstein, Singapore, Switzerland, Taiwan, and the United Kingdom.

2.2 Organization and Management

On January 1, 2004, Lukas Winkler became president and chief executive officer of the company. Dr. Linenberg heads the New Jersey facility where production, technical sales and marketing, and customer support for the Scentograph product line is presently carried on.

2.3 Operating Experience Related to the Technology

Inficon believes that much of their success with the Scentograph CMS 200 with SituProbe is attributed to the company's level of involvement with the user before and after they make a purchase. Already purchases of over 20 such systems have been made and these systems are operating at facilities across the United States and abroad. Also, about 5 to 10 CMS 500 Systems have been sold and installed. (CMS 500 is a fixed location version of the Scentograph CMS 200 with SituProbe formerly known as Aquaprobe) .

In all these cases, Inficon was involved in a complete, turn-key delivery of their System. This included going out to the proposed site to evaluate and consult on the proposed application. When necessary, sampling was conducted and samples were analyzed back at their New Jersey facility. Turn-key delivery meant Inficon's hands-on involvement with the specific design for the application, set-up, providing SOP's, training and oversight. As in the case of the Miami-Dade Water Authority, Inficon personnel occasionally operate and maintain the Inficon System on-site. This level of involvement has helped assure that clients obtain high quality performance from their products.

2.4 Proprietary Method

The main component of the Inficon System is gas chromatography, a well-established analytical technique used to identify and determine the concentrations of different organic vapors in a given sample. Gas chromatographs function by passing vapors through tubes called chromatographic columns, which contain liquid coated particles.

Inficon (as Sentex) has developed a proprietary method of preconcentrating and introducing the vapors in the test sample to the chromatographic column. This feature heightens the sensitivity of the company's products to atmospheric vapors. All Inficon's instruments also feature unique detectors developed by the company. These are capable of detecting certain difficult-to-detect compounds, such as chloroform and carbon tetrachloride, at extremely low (sub-ppb) levels.

There are no patents on file for the Inficon System on any of these unique components.

2.5 Technical Resources of Staff and Capital Equipment

The Scentograph CMS 200 with SituProbe is manufactured and supported out of the Fairfield, New Jersey facility. Six full time employees work at that location in production, marketing, product support and clerical administration. The company also contracts with several outside vendors and consultants in the area of electronic design, software development, mechanical design and marketing. The team is headed by Dr. Amos Linenberg, a Ph.D. chemist who has been developing on-site GC's for over 30 years. Inficon is in the process of transferring the production of the systems to Syracuse, New York where they will be produced within the company's ISO 9001 quality assurance protocol.

3.0 Design and Operation of Technology

The measurement system under this evaluation is being marketed as the CMS 200 Scentograph with SituProbe. The Inficon Scentograph CMS 200 with SituProbe is a computer-controlled, field-portable gas chromatograph (GC) with an attached probe designed to provide complete sample analysis, from calibration to interpretation of results. The technology is based on purge-and-trap sample introduction followed by gas chromatography. A laptop computer controls the complete process. The Inficon System performs the following functions;

- Autocalibration

- Purge and trap sample collection and injection
- Auto analysis at predetermined frequencies.
- chromatographic separation
- compound detection
- peak identification and integration
- data display and storage, including chromatograms, retention times, concentration levels, and operating conditions
- continuous operation
- recalibration at predefined frequencies
- optional remote operation

The SituProbe is attached to the Scentograph CMS 200 GC and inserted in the water stream or sample container. The water sample is drawn, using gravity or pumps, into a flow through chamber. The water enters the SituProbe glass sleeve through holes at its bottom and approximately one inch below its intake, assuring continuous circulation of the water sample within the probe's sleeve. An inert gas tube, located at the bottom of the SituProbe sleeve, initiates a flow of carrier gas, which efficiently purges the VOCs from the water and carries them to a sorbent trap, where they are adsorbed unto a sorbent material which is usually Tenax or Carbowaxen. The adsorbed VOCs are thermally desorbed from this material onto an analytical column for separation. As they are separated, the VOC vapors pass through a detector where they are identified and measured against analytical standards, previously run using the same protocol as the calibration run. Signals from the detector are used to report out retention time and area under the peak which together allow identification and quantitation. Data results are then reported out. A commercial type laptop computer is used to set operating conditions such as temperature, flow rate, purge cycle time, as well as to direct calibration and sampling frequencies. It also is used to control Inficon's data management software which helps in the identification, calculation, peak matching, data assimilation, data transmittal and quality control steps.

The technology provides a platform for operating in many different applications and in different ways. Many operational choices can be made, for example, type of detector, purge flow rate, chromatography conditions, and calibration method (single point or multi-point.) The technology is not being designed or evaluated here for a specific application/ methodology, but rather its ability to perform in a range of applications. For example, in a long term, fixed monitoring application, it may be only necessary to provide a single point, automatic calibration. In a more investigative monitoring mode, a multi-point, manual calibration may be more desirable.

The technology is operated to minimize cross contamination between samples. Because of its design, the large volumes of sample flow through the cell between purge cycles. For example, if the sample is purged every 15 minutes, the flow cell is about one liter and the water flow were as low as 4 liters per minute, the sample in the cell is being replaced about 60 times every cycle. This minimizes carryover significantly. Also, the system is equipped with a software command to activate several inputs in sequence. If needed, one of the inputs can be a clean, blank sample to monitor carryover.

The main components of the Inficon System are the Scentograph CMS 200 GC, SituProbe and laptop computer:

(a) Scentograph CMS 200 gas chromatograph

This is a portable type field gas chromatograph that is 48 pounds in weight and can be powered in the dc mode by re-chargeable batteries. For fixed-location operations, it can be connected to an ac source. It comes with an internal gas supply cylinder which is easily refilled and can provide about 8 hours of operational time. The cylinder can contain either high-purity argon gas for the MAID/ECD configuration or helium carrier gas for the photoionization detector (PID) or thermal conductivity detector (TCD).

The instrument consists of a GC module and a detector module. The GC module includes the oven, columns, and detector(s). Packed columns 3 mm in diameter and up to 3 m in length or capillary columns with 0.53-mm i.d. and up to 105 m in length are available. Two columns can be installed in the oven, which can adjust temperatures up to 179 °C. The oven is well insulated and maintains the temperature of the column, the on-column injector, and the detector(s). For optimum compound separation, two-stage temperature ramping is available.

The detectors are mounted in a compartment in the oven and heated to operating temperature. The instrument can be used with up to five different detectors, depending on the application. These are the:

Argon Ionization Detector – The AID provides sensitive detection of organic compounds having an ionization potential of 11.7 eV or below. These compounds include halomethanes and haloethanes, such as carbon tetrachloride and 1,1,1-trichloroethane, which are poorly detected by other common field detectors. This detector is capable of detecting these compounds, as well as other hydrocarbons down to low ppb levels.

Micro Argon Ionization Detector – The MAID is a small volume, higher sensitivity version of the AID. It is ideal for use with capillary columns with detection limits at the sub ppb levels.

Electron Capture Detector - The ECD is a selective detector used for the detection of halogenated hydrocarbons, PCB's, pesticides, and nitro-based compounds only. Its sensitivity can reach low ppt levels.

Thermal Conductivity Detector - The TCD is used primarily for the detection of natural gases in concentrations ranging from 100 ppm to percent levels.

Photoionization Detector- The PID uses an ultraviolet lamp to ionize and detect hydrocarbons having ionization potentials of 10.6 eV or less with sensitivity approaching the 1 ppb level.

The Scentograph CMS 200 functions in calibration and sample analysis modes. In the calibration mode, a water sample with known VOC composition is introduced into the

Scentograph CMS 200 for chromatographic separation. The software then displays the resulting chromatogram, including the name, concentration level, and retention time of each compound in the calibration mixture. The area under each peak is integrated and the concentration level of the standard is assigned to this peak area. Automatic multipoint calibration is also available.

The instrument has excellent potential for use as a dedicated monitor in a variety of monitoring applications, especially where there is interest around a single measurement point or "go-no go limit." For many of these applications, a single point calibration can be used. When there is interest in quantitation over a broader analytical range, multi-point calibrations should be used, as with any gas chromatograph. The instrument utilizes the same type detectors as a standard laboratory gas chromatograph and will provide the same linear dynamic calibration ranges, depending on the parameter, detector, operating conditions and quantitation level. In all cases, it is important that the desired quantitation range, instrument response and calibration method is completely evaluated and understood.

The instrument is equipped with an internal calibration cylinder that supplies gas directly to the calibration system. Calibration gas from the cylinder flows through a regulator and directly to the sample loop or preconcentrator.

In the sample analysis mode, the Scentograph CMS 200 is used to analyze field samples. The software displays the analysis chromatogram above the calibration chromatogram and identifies each peak as it appears. The names, concentration levels, and retention times of the compounds that match those identified during calibration are listed. Compounds detected that do not match those identified during calibration are listed as "unknown." Their retention times and concentration levels, compared with the first calibration peak, are also displayed. The "unknown" compounds may be identified by computer-assisted methods. Sample analysis results may be compared with other calibration results stored in the Scentograph memory, or libraries that contain hundreds of compounds may be scanned for retention time matches. Since calibration and sample analysis modes are operated under the same conditions, and because calibration can be performed as frequently as required, the analysis results obtained with the Scentograph CMS 200 are highly reliable and accurate.

Three methods can be used to introduce samples into the Scentograph CMS 200: a preconcentrator trap, a sample loop, or a heated injection port.

- Preconcentrator

The Scentograph CMS 200 is normally equipped with a preconcentrator for use when sample concentrations are expected to be less than 40 ppb in water. It is packed with an absorbent material such as Carbowaxen and can be varied according to the user's application.

- Sample Loop

A sample loop that allows the automatic injection of fixed volumes (usually 0.5 to 1.0 cc sample size) can be installed in place or parallel to the preconcentrator. This loop permits air analysis of sample concentrations between 1 ppm and 1000 ppm for most compounds. The sampling loop will also allow the detection of VOC's in water at levels of several thousands of ppm and should be used if concentrations are expected to exceed 10 ppm.

- Heated Injection Port

The Scentograph CMS 200 can be equipped with an optional heated on-column injection port for syringe injection of gas or liquid. The injection port is primarily used for the analysis of pesticides and PCB's via liquid injection. Direct injection of gas samples will attain sensitivities similar to using a sample loop. An accessory for an on-column injection to capillary columns is also available. The Scentograph CMS 200 is equipped with an automatic sampling pump with an intake rate of approximately 80 cc per minute to input sample into the preconcentrator or sampling loop from the internal calibration system, the external calibration port, or the analysis port.

(b) SituProbe

VOC's in water can be analyzed with the Scentograph CMS 200 by use of an attachment known as the SituProbe, an in-situ continuous purge device. The SituProbe is constructed of inert materials such as teflon, glass, peek and platinum. Once inserted into the water, the probe can either be attached to a flotation device or otherwise supported to maintain a certain depth in the water. The depth of the probe does not affect the operation of the Inficon System. The probe, like the GC, is portable and can be carried to various locations to perform the analysis. (A fixed location version called the Scentograph 500 is also available. This Inficon System is highly suited to industrial applications where the entire unit is enclosed and protected from ambient interference.) After the operator connects the SituProbe tubing and electrical cables and programs appropriate operating parameters, samples can be automatically drawn from the glass purging cell through which the water sample continuously flows, stopping short of reaching the purge input. During this time, the VOC's can be purged into an adsorption trap and then onto the gas chromatograph. The SituProbe purge method can be used to detect low concentrations of VOCs in water. In most cases, concentrations will range from sub-parts-per-billion levels to hundreds of parts per billion. Higher concentrations (i.e., above 200 ppb) are normally detected using headspace analysis by syringe injection of the headspace or by trapping headspace volumes directly.

(c) Laptop Computer

Inficon supplies a detachable notebook personal computer with the Scentograph CMS 200. . The Inficon software program that controls the instrument is contained on the hard drive of the PC. Chromatographic data can be stored on the computer or transferred to other systems.

4.0 Technical Performance Claim

Claim: *The Inficon Scentograph CMS 200 with SituProbe is capable of performing real-time, on-line monitoring for VOC's of regulatory concern down to relevant detection levels, and with data quality that is comparable to the prescribed (USEPA) analytical method.*

5.0 Technical Performance

As stated before, this technology has moved well into commercialization and acceptance by customers in the United States and overseas. Over 20 such systems are already in use. In support of the above claim, Inficon has identified three independently conducted evaluation studies. These are the Environmental Technology Verification (ETV) study conducted by USEPA in September, 1997, the Weyerhaeuser Flint River Study by Weyerhaeuser in the fall, 2001 and the Ohio River Study by the Cincinnati Water Works Laboratory in March, 2002. The first study, which was the ETV Study, was conducted by USEPA and other federal organizations in order to evaluate innovative measurement technologies for users, especially in hazardous waste site remediation. Private users, who had interest in on-line VOC monitoring applications, conducted the other two studies.

All three organizations evaluated the Scentograph CMS 200 with an automated purge and trap device. . The two more recent studies, the Ohio River Study and the Weyerhaeuser Study used the SituProbe, designed in its most present state. The ETV study used the earlier version of the purge probe, which had to allow the water sample to be pumped into a cell rather than being continuously drawn in and out, as is the case with SituProbe. This new enhancement of continuous flow-through allows for expanded sample volumes during the purge cycle, therefore providing greater measurement sensitivity. Also, because the Situprobe draws in rather than pumps in the water sample, there is less likelihood of VOC losses through volatilization and problems associated with highly turbid and oily samples. These problems can make analysis difficult and sometimes impossible.

5.1 Case Studies

a) Environmental Technology Verification (ETV) - Environmental Technology Verification Report, EPA/600/R-98/145, U. S. Environmental Protection Agency, July 26, 1999 (Ref. 3)

The USEPA, through the ETV Program, tries to foster the use of innovative technologies to help address the nation's environmental problems. As part of that Program, USEPA participates along with the Department of Defense and the Department of Energy in the Consortium for Site Characterization. The Consortium conducted a field demonstration (verification) of the Scentograph CMS 200 along with four other field analytical technologies in September, 1997. The demonstration was aimed primarily at technologies for the analysis of chlorinated volatile organic compounds in groundwater. It was held at two geographically and climatologically different sites: the U. S. Department of Energy's Savannah River site at Aiken, South Carolina and McClellan Air Force Base, near Sacramento, California.

The Inficon technology was subjected to a rigorous evaluation by the Consortium which included sample throughput, completeness, analytical versatility, precision, accuracy, comparability, ease of operation, operator training requirements, transportability, versatility and ease of deployment.

The evaluation was aimed at determining a number of performance factors of the Inficon System. These included:

(1) Precision: Assessed at each site with 8 mixtures of blind replicate samples. These performance evaluation (PE) samples were made from certified chlorinated VOC standard mixes and were verified by the project reference laboratory. Precision was measured as relative standard deviation.

(2) Accuracy: Assessed with PE samples at each of the two sites, also verified by the project reference laboratory. A mean recovery was computed for each reported compound in the PE mixture. The average instrument result for each compound, based on four blind replicate sample analyses, was compared against the known concentration in the PE mixture and reported as % recovery and absolute % difference.

(3) Blank sample response: Two or more blind blanks per day accompanied groundwater sample batches at each site. These were prepared from deionized, carbon-filtered water. They were used to assess the false positive rate.

(4) Low level measurement capability: At each site, 10 blind, replicate, spiked samples were provided for analysis to assess the capability of the Inficon System to measure at low levels, typical of regulatory compliance levels.

(5) Sample throughput: An assessment was made of the number of samples that could be processed over a time period.

(6) Comparability: An assessment was made of the comparability of the Inficon System against the project reference laboratory which used USEPA method 8260A. This was made by computing the absolute % difference and the linear regression on test results for all groundwater samples.

(7) Qualitative Factors: A number of qualitative performance factors were assessed during the course of the verification. These included instrument portability, logistical support requirements, operator training requirements, and ease of operation.

The Scentograph CMS 200 with attached probe was challenged with a wide variety of chlorinated VOC's of regulatory interest. These were contained in both the synthetically prepared performance evaluation and the groundwater samples at the sites. A list of the certified mixes that were used for the preparation of the PE samples is shown below:

PE Mix 1 – Purgeable A Supelco Cat. No. 4-8059 Lot LA68271	PE Mix 2 – VOC 3 Supelco Cat. No. 4-8779 Lot LA64701	PE Mix 3 – Purgeable B Supelco Cat. No. 4-8058 Lot LA 63978
Trichlorofluoromethane	1,1-Dichloropropene	1,2-Dichloroethane
1,1-Dichloroethane	1,2-Dichloroethane	1,1,2,2-Tetrachloroethane
Dichloromethane	Trichloroethene	Cis-1,3-Dichloropropene
1,1-Dichloroethene	1,2-Dichloropropane	Trans-1,3-Dichloropropene
Chloroform	1,1,2-Trichloroethane	Trans-1,2-Dichloroethene
Carbon tetrachloride	1,3-Dichloropropane	1,1,1-Trichloroethane
Trichloroethene	1,2-Dibromoethane	Benzene
1,2-Dichoropropane	1,1,1,2-Tetrachloroethane	Bromodichloromethane
1,1,2-Trichloroethane	1,1,2,2-Tetrachloroethane	Toluene
Tetrachloroethene	1,2,3-Trichloropropane	Ethyl benzene
Dibromochloromethane	1,2-Dibromo-3-chloropropane	Bromoform
Chlorobenzene	Cis-1,3-Dichloropropene	
1,2-Dichlorobenzene	Trans-1,3-Dichloropropene	
2-Chloroethyl vinyl ether	Hexachlorobutadiene	

At each site, mixtures of these VOC compounds were made into a total of 42 test samples. These contained concentrations in the 1 – 10, 50, 100, 200, 600 and 800 ug/L ranges. Also a set of replicates was made of samples that were spiked at about the 1 mg/L level. In addition, 8 blank samples made out of deionized, carbon-filtered water were provided.

A total of 33 groundwater samples were provided at each site to Inficon as well as the project reference laboratory. The samples were taken from each of 10 wells by verification contractor personnel. Target compounds at Savannah River were trichloroethene and tetrachloroethene. At McClellan Air Force Base they were trichloroethene, tetrachloroethene, 1,2-dichloroethane, 1,1,2-trichloroethane, 1,2-dichloropropane, and *trans*-1,3-dichloropropene.

An additional evaluation was carried out by means of field audits. Auditors were from the Environmental Technology Verification (ETV) Program being carried out in partnership between the EPA National Exposure Research Laboratory in cooperation with the Sandia National Laboratories, the testing partner. The auditors conducted inspections during the demonstration and reviewed:

- description of equipment used;
- logistical considerations, including size and weight, shipping and power requirements, other required accessories;
- historical uses and applications of the technology;
- estimated cost of the equipment and its field operation;
- number of operators required;
- required operator qualifications;

- description of data produced;
- compounds that the equipment can detect;
- approximate detection limits for each compound, if available;
- initial calibration criteria;
- calibration check criteria;
- corrective actions for unacceptable calibrations;
- specific QC procedures followed;
- QC samples used;
- corrective action for QC samples;
- sample throughput rate;
- time requirements for data analysis and interpretation;
- data output format and description;
- specific problems on breakdowns
- possible matrix interference;
- other auditor comments and observations

For the demonstration, the Inficon System was set up and operated in a folded down center seat of a mini-van. Three components to the Inficon System were assembled. These were the field portable sample purge system (called the Aquascan), the Scentograph CMS 200 gas chromatograph and a laptop computer. The Inficon System was operated with ac and argon carrier gas was used from the internal gas cylinder.

Samples were handled in the same manner at both sites. Chilled water at about 4° C was supplied in 250 mL amber bottles with zero headspace. If necessary, Inficon, based on advised concentration ranges, would make dilutions. Water samples were withdrawn at a rate of 150 mL/ minute for 60 seconds and flushed through a 10 mL sparge cell using a motorized impeller pump in the purge unit. Argon gas was bubbled through the 10 mL sample volume and the entrained vapors routed through tubing to a sorbent trap in the GC module. Following the adsorption cycle, the sorbent trap was heated and carrier gas was passed through the trap to move the vapors into the head of the column for separation and quantitation. All purge and trap GC analysis functions were computer controlled and were initiated by the instrument operator with keyboard commands. The gas chromatograph was operated with the Micro Argon Ionization Detector (MAID). Inficon used a 3 point calibration protocol for this evaluation. Proprietary software was used to run all events. Final data were provided to the verification organization in spreadsheet format on a disc.

The ETV Program compiled a verification report covering the demonstration. In that report, it was stated that the demonstration provided adequate analytical and operational data with which to evaluate the performance of the Scentograph Plus II gas chromatograph (now called the Scentograph CMS 200). Evaluation data included both comparison to known values of PE samples (for precision and accuracy testing) as well as comparison with a fixed-base analytical laboratory (for well samples.) Instrument precision and accuracy were determined by an analysis of replicate samples from 16 multicomponent standard mixtures of known composition. The relative standard deviations, obtained from an analysis of 4 replicate samples from each of the 16 standard mixtures, were used as measures of precision. The relative standard deviations from all compounds had a median value of 8% and a 95th percentile of 32%. Accuracy was expressed as

the absolute percent difference between the Scentograph Plus II measured value and the true value component in the standard mixtures. The distribution of absolute percent difference for all reported compounds had a median reported value of 10% and a 95th percentile value of 38%. It should be understood that for the precision and accuracy studies that all possible constituents were disclosed by ETV to all the participants, including the reference laboratory. A comparison of Scentograph Plus II and reference laboratory results (using SW-846, 8260A) from 33 groundwater samples at each site resulted in a mean absolute percent difference of 12% with a 95th percentile value of 194%. In this comparison, Inficon personnel conducted the field analysis while the reference laboratory staff conducted the laboratory analysis. DataChem Laboratories was chosen as the reference Laboratory for this project. This was a full-service laboratory in Salt Lake City, Utah and was an EPA CLP Laboratory had had a number of state-specific certifications including New Jersey. A correlation analysis between Scentograph Plus II and laboratory resulted in a correlation coefficient greater than 0.96 at low (<100ug/L) contaminant concentrations. Correlation coefficients were greater than 0.91 at high (>100ug/L) contaminant concentrations. The sample throughput rate was determined to be two samples per hour. The Scentograph Plus II cost was about $35,000 for a single detector, single column, single-column configuration, and can be operated by a field technician with a minimal training in gas chromatography. Of course, chemist supervision, as always is needed.

The report concluded that "under appropriate applications, the Scentograph Plus II can provide useful, cost-effective data for environmental site characterization and routine monitoring. The instrument can be deployed in a variety of applications, ranging from producing rapid analytical results in screening investigations to producing accurate and precise data that are directly comparable with that obtained with an off-site laboratory. This data could be used to develop risk assessment information, support the remediation process and fulfill monitoring requirements. As with any technology selection, the user must determine whether the technology is appropriate for the application by taking into account instrument performance and the project's data quality objectives."

b) Weyerhaeuser Study - Private Communication: "Results of Analysis Using Sentex Scentograph Plus II Gas Chromatograph with the SituProbe for Methanol Analysis in Weyerhaeuser Flint River Plant," Terrill Aldrich, Flint River Operations, Oglethorpe, Georgia, November, 2003 (Ref. 4)

In January, 2001, the Weyerhaeuser Paper and Pulp Plant in Oglethorpe , Georgia, initiated a program to evaluate the Inficon System for monitoring methanol in condensate streams and wastewaters. Methanol measurement and removal was an important issue for such companies in order to comply with the USEPA Cluster Rules. Manual laboratory methods for monitoring methanol were available from the USEPA (method 301) and also the National Council of the Paper Industry for Air and Stream Improvement (NCASI), but Weyerhaeuser was interested in a method that could be used on-line and provide real time information on changing methanol conditions in a plant. Inficon brought the Scentograph CMS 200 with SituProbe to the Weyerhaeuser plant in South Georgia for evaluation. The Inficon System was to be evaluated for capability for providing continuous unattended operation and automatic on-line monitoring of methanol in the water stream. The evaluation also needed to address maintenance and calibration requirements and comparability of data with the established laboratory method. The

established laboratory method was NCASI Method DI/HAPS 99.01 which was developed and approved by EPA against the EPA Method 301 regulatory method.

The evaluation was conducted by Terrell Aldrich and staff from the Weyerhaeuser Flint River Operations. The evaluation project results are described in "Results of Analysis Using Sentex Scentograph Plus II Gas Chromatograph With the SituProbe for Methanol Analysis in Weyerhaeuser Flint River Plant," communication document.

The Inficon System was housed in a 6 ft by 4 ft by 7 ft wooden enclosure that was placed in the sampling locations in condensate streams, at the waste clarifier and in the lagoon. Power, argon gas and telephone lines were connected to it. Both automatic on-line and manual batch processing testing was carried out. Comparisons were made of the Inficon System on-line results with those from samples taken at the approximate time and locations and analyzed by two commercial laboratories using the USEPA 301 method. The laboratories were the AT&T Analytical Chemistry Laboratory, in Federal Way, Washington and Severn Trent Services, Savannah, Georgia.

c) Ohio River Study for VOC's in drinking water - Private Communication: "Continuous On Site Monitoring of VOC's in Water Sources." Patty Harlinger, Cincinnati Water Works, Cincinnati, Ohio, November, 2003 (Ref. 5)

The Ohio River Valley Water Sanitation Commission (ORSANCO) was seeking to evaluate new technologies which could allow more frequent and accurate monitoring of the Ohio River with minimum resource requirements. There was interest in using these monitors as early warning devices of possible contamination from spills or other intentional or unintentional causes that might be taken up by water treatment plants. At present, there are several upriver testing stations but they send the samples to fixed-base laboratories. Faster analysis was desired.

At the request of ORSANCO, the Cincinnati Water Works Laboratory in Cincinnati, Ohio conducted an evaluation of the Scentograph CMS 200 with SituProbe. The evaluation was carried out to determine if the Inficon System could be used to provide a reliable measurement of organic contaminants that could potentially be received into intake water from the Ohio River. The Cincinnati Water Works staff conducted the evaluation and provided an evaluation report "Continuous On Site Monitoring of VOC's in Water Sources." The report was received from Patty Harlinger, Cincinnati Water Works, Cincinnati, Ohio. (private communication.)

The purpose of their study was to determine if the Inficon System was a reliable alternative for initial river screening on some common organic contaminants. ORSANCO's requirement was to conduct a demonstration which placed the technology in a "humanly protected area," representative of where they wanted to do their river monitoring. This area would be one where operators could conveniently operate the system, and where a lap-top computer could survive. It was desirable to have both heating and air-conditioning in the area. Samples would be drawn up into this area for testing. At the Cincinnati facility, a performance evaluation sample was prepared for this evaluation. It was prepared from a standard mixture of commonly suspected VOC's and at an initial concentration level of 5 ppb. Preparation was done in a one-liter volumetric flask. A 40 mL vial was then filled from the flask and the rest of the contents of the flask were placed in a

container. The SituProbe was then placed into the container and sampling was started. The Inficon System used a MAID detector in the CMS 200 with dual sequential columns. A single point calibration was conducted. While the Inficon System was running the vial was loaded unto an autosampler set up for USEPA method 502.2 to be run at the Cincinnati laboratory. This was an automated system, which consisted of a vial autosampler, Tekmar 3000 Purge and Trap Concentrator and a Varian GC with dual PID and ELCD detectors. A five-point calibration was used.

The process was repeated five times over several different days to determine if the calibration would hold and that the results were in agreement with the USEPA method. The following VOC's were the target analytes in the PE sample:

1,1-Dichloroethylene (ICE2)
Methlylene chloride (IDIC)
1,1-Dichloroethane (ICC1)
Chloroform (ICLR)
1,1,1-Trichloroethane (I3C3)
Benzene (BENZ)
Trichloroethylene (IET3)
Bromodichloromethane (ICL2)
1,2-Dichloropropane (ICP1)
Tetrachloroethylene (IC4E)
Dibromochloromethane (ICB2)
Chlorobenzene (CBEN)
Ethylbenzene (EBEN)
Styrene (STYR)
Bromoform (ICB3)
1,2-Dichlorobenzene (BNZO)

5.2 Verification Procedures

These data and information from the three studies have been reviewed to verify the Inficon claim for the Spectrograph CMS 200 with SituProbe, stated in section 4 of this report. For purposes of verification, the claim for the water monitoring technology is divided into three parts: *The Inficon Scentograph CMS 200 with SituProbe is capable of:*

(a) performing real-time, on-line monitoring for VOC's
(b) of regulatory concern down to relevant detection levels and
(c) *with data quality that is comparable to the prescribed (USEPA) analytical method.*

a) real time, on-line monitoring of VOC's

Both the Weyerhaeuser Study and the Ohio Review Study sought to evaluate the technology's capability to provide real-time, on-line VOC data.

Weyerhaeuser challenged the technology to run in a continuous mode at their South Georgia plant, measuring the constantly changing methanol levels in their condensate

streams. The SituProbe was placed directly into water streams to provide continuous, unattended monitoring of methanol. The technology was operated continuously for several months. Single point calibration was performed once a week and calibration checks were conducted daily. For this application, single point is all that was needed and that was considered a complete calibration. The complete calibration was conducted as follows: Four 2 liter Methanol in water solutions and a clean water blank solution were prepared and brought to the ambient temperature of the condensate by immersing the containers in the sample line. The probe was then placed in the containers, one at a time. Calibrations were run at normally the 8000 to 10000 PPM levels, as chosen by the operators. Calibration was repeated until establishing consistency between samples. Calibration checks were conducted once daily at the 8000 to 10000 PPM level and had a criteria of within 10% agreement. After the results were reviewed, processed, summarized and converted to excel and bmp files, Inficon emailed them back to Weyerhaeuser. A close to real-time instrument response of methanol was conducted every 14 minutes. This is shown by continuous monitoring data obtained on August 6th at 22:10 hours to August 7th at 01:35 hours. During this time, measurements of methanol were made in the 0 to 18,000 ppm range (Ref. 6).

The Inficon System was also tested at the Cincinnati Water Works facility for its on-line, real-time capability. The evaluation setup was intended to simulate an on-line situation, placing the SituProbe in a sampling container and operating it close to the Ohio River. In a real situation, the river water could have been drawn up and passed through the container as the Inficon System would conduct its measurements. However, in order to evaluate comparability with the Cincinnati laboratory running the USEPA method, a PE sample was used which could provide known and measurable VOC compounds. In order to accommodate this need, the PE sample had to be placed in the container without any actual flow-through of water. Nevertheless, the Inficon System did provide measurement data in this simulated system over a period of time, using a single point calibration. Although there is no data on the turn-around time for results, the Inficon System probably could have reported a full analysis result in less than 30 minutes elapsed time.

b) of regulatory concern down to relevant detection levels

Many of the environmental applications for the Inficon System will be probably directed toward a regulatory related or mandated use. Most of the specific VOC's and required measurement detection levels will be listed in the regulations and analytical methods derived from the Clean Water Act (CWA), Safe Drinking Water Act (SDWA), and Resource Conservation and Recovery Act (RCRA) as well as in state equivalent regulations. All three of the above studies evaluated the Inficon System for its ability to detect and measure these commonly listed VOC's.

In the ETV study, the Inficon System was able to detect and measure 19 of the 32 provided VOC compounds present in the PE samples. Inficon was limited to reporting only the ones for which they brought analytical standards for calibration. All 19 compounds reported were VOC's that had significant regulatory interest typical of those in groundwater and surface water. These are shown below:

PE Compounds Calibrated and Reported	
1,1-Dichloroethene	1,1,2-Trichloroethane
Dichloromethane	Tetrachloroethene
1,1-Dichloroethane	Chlorobenzene
1,2-Dichloropropane	1,1,1,2-Tetrachloroethane
Carbon tetrachloride[(a)]	cis-1,3-Dichloropropene
1,2-Dichloroethane[(a)]	trans-1,3-Dichloropropene
Trichloroethene	1,2-Dichloropropane
Toluene	Benzene
Ethyl benzene	trans-1,2-Dichloroethene
1,1-Dichloropropene	

For the groundwater VOC compounds for which it was calibrated, the Inficon System detected 35 of the 62 compounds compounds reported by the reference laboratory at concentration levels in excess of 1 ug/L. Again, these were the ones for which Inficon brought analytical standards and were able to calibrate. The compounds reported also represent VOC compounds of significant interest.

It should be noted both for the PE and groundwater samples that the ETV study included the evaluation of other field technologies, including one which might be applied to broader "screening" applications of multi-component mixtures. The Inficon System was not intended for such applications, but rather those where the specific analytes of interest are known or suspected and can be targeted for analysis.

The ETV study also challenged the ability to detect VOC compounds at very low concentration levels (10µg/L) on 10 replicate samples. This tested the technology's capability to perform at or near regulatory action levels.

The Inficon System was able to detect 16 of the 18 compounds provided in all 10 replicates without any false negatives. On 1 compound, 1, 2-dichloropropane, the Inficon System detected 7 out of 10 times for a 30% false negative rate. On 1 compound, 1.2 dichloroethane, the Inficon System failed to detect the compound in any of the replicates.

In the Ohio River Study, the Cincinnati Water Works also included the objective of determining the capability of the Inficon System to detect and quantitate VOC's at low levels in water. The study chose what was believed to be common organic contaminants. These included 14 VOC compounds (shown in section 5.1), both chlorinated and non-chlorinated which covered the 4 trihalomethanes and other compounds on the unregulated Drinking Water Contaminant List. A PE sample was prepared to contain these 14 VOC compounds at a concentration level of 5 ppb. This would be a realistic level for early warning monitoring. The Inficon System detected and measured all 14 VOC compounds.

In the Weyerhaeuser study, methanol was of concern because it was being regulated at the plant under the Cluster Rules. A regulatory target limit of 200 ppm was established. The Inficon System demonstrated the ability to detect and measure at levels lower than that on both the waste clarifiers and lagoon at the plant. Also, this Inficon approach has been accepted for methanol monitoring by the state of Georgia DEP.

c) data quality that is comparable to the prescribed (USEPA) analytical method

Data comparability to regulatory methods was evaluated in all 3 studies. Essentially this is a determination that the candidate technology or method, the Scentograph CMS 200 with SituProbe, will provide equal or better performance than the reference method or known true value. Three important measures of this are precision, accuracy and comparability.

(a) Precision

The ETV Study evaluated precision achieved on replicate analysis of the PE samples. Performance was compared to a pre-approved contract laboratory that conducted the EPA 8260A method from SW-846, "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods." On all compounds replicated, the Inficon System provided a median RSD of 8% and a 95th percentile RSD of 32% compared to the reference laboratory's median RSD of 7% and a 95th percentile of 25%. The Inficon System demonstrated excellent performance for precision.

In the Weyerhaeuser Study, an evaluation was made of the internal precision of the Inficon System in two ways. Four different samples prepared at 10,000 ppm concentration of methanol were run three times each. The RSD was calculated to be 4.3%. Also, a 5000 ppm test sample kept at constant temperature in a two-liter volume was analyzed 150 consecutive times. The reproducibility was calculated to be an RSD of 2.26%.

(b) Accuracy

In the ETV Study, accuracy was expressed as the absolute percent difference between the Scentograph CMS 200 measured value and the true value component in the standard mixtures. The distribution of absolute percent difference for all reported compounds had a median reported value of 10% and a 95th percentile value of 38%.

(c) Comparability

In the ETV study, a comparison was made between the Inficon System and the reference laboratory, using USEPA SW-846 8260A on 33 groundwater samples from each of the sites. This was done in two ways. First, an APD was determined between the Inficon System and laboratory on all groundwater compounds mutually detected. This was calculated to be 12% with a 95th percentile of 194%. This indicates very good agreement between the Inficon System and the laboratory using the USEPA method 8260A.

Second, a correlation was calculated for all compounds detected between the Inficon System and the laboratory. The correlation coefficient (r) was 0.974 for all compounds below 100 ug/L at Savannah River and 0.959 at McClellan. At concentrations above 100 ug/L, the coefficients were 0.907 for Savannah River and 0.997 for McClellan. This comparability is considered excellent for a field type system.

In the Weyerhaeuser Study, the Inficon System was compared to two outside commercial testing laboratories using the approved USEPA method. Comparison was made on samples from condensates, the clarifier system and lagoons. The samples sent to the laboratories represented condensates which were collected over a period of a few hours each, while the samples analyzed by the Inficon System represent concentrations measured over shorter periods of time. Seven samples were taken from March 4, 2002 to March 10, 2002 both on the condensate and waste clarifier cell 1. Sample results were compared between the two laboratories and the Inficon System and showed excellent agreement. Deviations between the laboratories, compared together, varied from 11% for condensate samples to 17% for treated samples. The results obtained from the Inficon System deviated 4% and 7% respectively from the laboratories' results for the treated samples.

In the Ohio River Study, the USEPA drinking water method 502.2 was considered as the reference for comparison. Although a standard of 5.0 ppb was used as a test sample, it is not reasonable to assume the value kept constant at a known value over the several day period. VOCs would be difficult to maintain at exactly that level. Therefore the values obtained by the Cincinnati Water Works Laboratory are regarded as the reference for comparison purposes. Means for 5 measurements of each compound are calculated and compared. Based on compound-by-compound comparison of these means, the Inficon System provided an overall average % difference (APD) of 12.5% from the laboratory. These differences in means ranged across individual compounds from 9% to 31%. There was agreement on all but one compound of within 20%. This demonstrates excellent agreement over the time period of comparison.

6.0 Technical Evaluation Analysis

6.1 Verification of Performance Claim

Based on a review of performance data from the three studies, sufficient data exists to support Inficon's claim.

SUMMARY OF PERFORMANCE

	ETV Study	Weyerhaeuser Study	Orsanco Study
Real-time, on-line		Continuous measurement for several months at 8000-10,000 pm level, using a single point calibration	Operated over a period of time, in a simulate river monitoring evaluation, using a single point calibration
Compounds of regulatory concerns at regulatory detection limits	Detected 16 out of 18 commonly expected groundwater contaminants at 10 ug/L without any false negatives	Monitored methanol at established regulatory limit of 200 ppm for EPA cluster rules	Measured 14 common to water organic contaminants at 5 ppb level
Comparable to regulatory methods - precision - accuracy - comparability	 On all compounds measured, obtained a median RSD of 8% and 95th percentile of 32% comparing favorably to a fixed laboratory using SW – 8260A Distribution of all absolute percent differences on all reported VOC's in PE samples had a median of 10% and a 95th percentile of 38% Compared results to a fixed-lab using SW 8260A. APD between Inficon and	 RSD of 4.3% on 10,000 ppm methanol sample; 2.3% RSD on a 5000 ppm sample Inficon results compared against 2 outside labs deviated by 4 to 7%	 Results compared with fixed-lab using EPA 502.2 showed overall average %

	lab was 12% with a 95th percentile of 194% Coefficient of correlations between Inficon and Lab was 0.974 and 0.959 on concentrations below 100 ug/L; 0.907 and 0.997 for concentrations above 100 ug/L		difference of 12.5%

6.2 Limitations

Because the Scentograph CMS 200 with SituProbe is designed and can be packaged with a variety of options, it should be able to potentially achieve desired objectives for many VOCs in water applications. However, there are several limitations to consider.

The Inficon System is ideal for situations where target analytes are known or predicted as demonstrated well in the Weyerhaeuser and Ohio River applications. However, the Inficon System is not designed to be a screening instrument that can simultaneously monitor for a broad range of compounds as shown in the ETV study. The Inficon System can be broadened in scope by using multiple columns and multiple detectors to increase the range of monitored compounds, but only to a degree.

Also, as with all gas chromatography methods, occasional confirmation should be made to verify results, especially those obtained with single column, single detector or single laboratory. To assure results are conclusive, confirmation checks on data from the Inficon System should be made periodically using other columns, detectors, and standards as well as verifying the data periodically against the reference method.

Although the Inficon System is considered relatively simple to operate, it does not eliminate the need for a well-trained chemist or technician. Training, as well as routine proficiency testing on quality control samples, is highly important.

7.0 Net Environmental Benefits

The driving forces behind water and wastewater testing are the federal Clean Water Act and the federal Safe Drinking Water Act. The Clean Water Act effectively limits, under the National Pollution Discharge Elimination System (NPDES,) the levels of certain “priority pollutants” (mostly VOC’s that both industrial companies and municipalities can discharge into a receiving stream.) In order to maintain an NPDES permit, each discharger is required to monitor its effluent discharges. Until now, dischargers could only meet those requirements by taking periodic samples and sending those samples to a commercial environmental laboratory to be analyzed. Since the Scentograph CMS 200 with SituProbe

can detect VOC's at levels equal to the detection limit of fixed base laboratory GC's, outside laboratory costs can be eliminated.

The Safe Drinking Water Act regulates the quality of the nation's drinking water supply. Recent regulations issued under the Act, known as the disinfection byproduct rules, lowered the maximum levels of Trihalomethanes allowed in drinking water and set new levels for six other VOC's commonly found in drinking water. These compounds are all byproducts of the chlorination process used by most water utilities and municipalities to disinfect drinking water. The Scentograph CMS 200 with SituProbe System is the only field-based GC capable of detecting these compounds at the new levels.

In 1998, the EPA finalized a set of regulations commonly known as the "Cluster Rules." In summary these federal regulations require the Paper and Pulp industry, among others, to control and reduce the discharge of VOC's into the environment. Methanol is a toxin of major concern routinely discharged at paper mills. Inficon's System is the only one available that will detect methanol on-site, immediately and continuously. These illustrate only several of the many applications where the Inficon System can provide saving costs, time and provide better information for environmental decision-making.

In terms of other environmental benefits, it should be realized that this technology, which is deployed in the field, eliminates the need for constant transportation of samples from the field to the fixed-base laboratory. This will result in reduced transportation exhaust emissions and use of fuel.

Also, using field approaches can reduce the need and size of fixed-base laboratories and their related infrastructure costs of energy for lighting, heating, operating equipment, air conditioning as well as handling, and laboratory waste disposal.

8. References

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