On-line Water Quality Monitoring as a Security Program

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ABSTRACT

In order to allow for regular and constant water quality monitoring, providing early detection of a contamination in a public water supply, Man-Tech has designed the TitraSip SA Near-Line system. This system allows for the connection of flowing taps from various process streams from the plant to an automated system in the laboratory for water analysis. Alternatively, an autosampler can be used for analysis of field samples. The system can rapidly analyze many parameters such as pH, alkalinity, conductivity and turbidity, all following EPA-Approved methods. Calibrations, quality control checks and sampling can occur at user-specified time intervals, with data automatically exported and any out-of-range results being flagged and/or setting off warning alarms for more immediate notification and appropriate action. Results for a number of different samples and concentration ranges are presented.

INTRODUCTION

Continuous water quality monitoring is a necessary protocol in order to provide early detection of problems or contamination events that may arise. Since time is a factor when considering the public water supply and awareness of any contamination is crucial to prevent illness, Homeland Security Presidential Directive 9 assigned the US Environmental Protection Agency (EPA) the task of looking at current monitoring programs for water quality that can help provide early detection of contamination. In response to this, the EPA developed a guideline for drinking water utilities that provides information on sampling for unknown contaminants in drinking water. This includes information and recommendations involving sampling for both routine and baseline monitoring, sampling in response to a triggered event, and emergency response plans.

Laboratories must develop appropriate standardized procedures for both routine and baseline sampling to establish normal levels of certain contaminants as well as to detect an abnormal event quickly. Procedures must also be in place for emergency contamination response, including sampling methods in response to triggered events. The awareness that early detection of contamination is crucial when considering the public water supply has led to the development of Man-Tech's TitraSip SA Near-Line system (Figure 1).

The TitraSip SA can be used by both the plant and the laboratory as an integral part of a drinking water utility's monitoring and emergency response procedures. Process streams running from the plant flow into the laboratory and are connected to the TitraSip SA for

automated sampling and analysis of various EPA-Approved methods such as pH, alkalinity, conductivity, turbidity, and many others. The system also includes an autosampler for the laboratory's routine analysis of field samples. In the same batch, process and field samples are monitored and analyzed utilizing identical methods, system, reagents and operators generating results that are directly comparable with full confidence in the quality and accuracy of the results. Calibrations, quality control checks and sampling occur at user-specified time intervals and run unattended, data is automatically exported and monitored for compliance, and in the case of a contamination event, an alarm can be triggered to warn of a potential hazard and the system will automatically grab aliquots of these samples and dispense them into separate containers for further analyses. These capabilities will enable the appropriate authorities to respond quickly to public health security or bioterrorism, therefore appropriate emergency response measures can be taken.

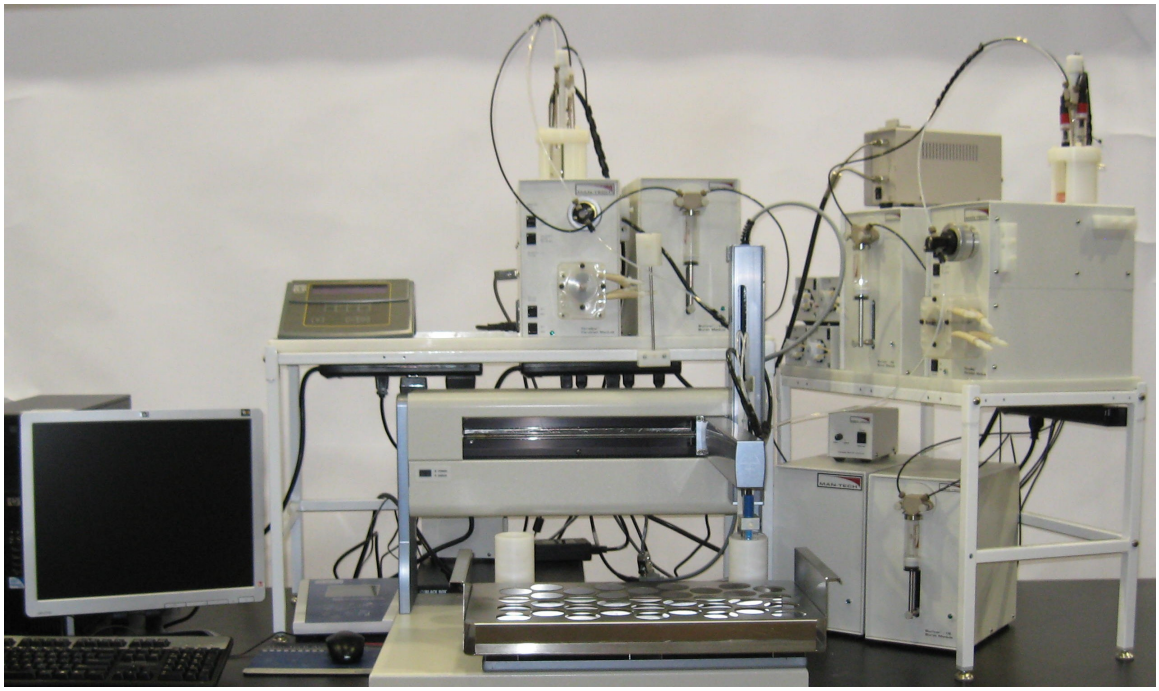

Figure 1: TitraSip SA Near-Line System for monitoring pH, conductivity, alkalinity, hardness and dissolved oxygen

The EPA is focused on protecting the nation's water resources, to help solve environmental problems and to understand how pollutants and contaminants in the water supply can affect the health of the public. They recognize the need for ongoing environmental monitoring, and in an effort to expedite the introduction of new environmental technologies into the marketplace, the Environmental Technology Verification (ETV) program was established. The ETV Program is in place to verify the performance of monitoring technologies to assess environmental quality. Continuous multi-parameter water quality monitors like the TitraSip SA are considered to be a high priority technology.

A verification study was performed on the Man-Tech TitraSip SA to evaluate its capabilities as a water quality monitoring system to continually measure pH, alkalinity, conductivity, chlorine, turbidity and temperature in drinking water. The study included assessments for accuracy, the system's response to injected contaminants, its reproducibility between systems and its ease of use. As a result of the study, the TitraSip SA was verified by the US EPA's Environmental Technology Verification Program.

PROCEDURE

Hardware

The TitraSip SA includes a personal computer, an interface, a TitraSip module and any combination of burets, meters, and electrodes depending on the parameters being measured. The system runs 100% unattended due to the capability of automatic sampling. The sampling system connects directly to flowing taps from various process streams via overflow stations, from which the TitraSip SA will automatically sample. This allows the same system to be used in either a laboratory or a plant ensuring identical systems are used for cross checks and verification, all following EPA approved methods.

The TitraSip module is an integral component of the TitraSip SA system. The TitraSip dosing pump accurately pipets sample into an analysis vessel located atop the module. A pinch valve beneath the vessel opens and closes on command to either contain or drain sample as required. A rinse pump utilizing Man-Tech's IntelliRinse technology quickly delivers deionized water to the analysis vessel eliminating any potential of carryover between samples. Multiple parameters are analyzed in turn within the analysis vessel, or a second TitraSip may be employed for simultaneous analysis, providing even faster results.

Figure 2: The TitraSip module

The TitraValve consists of a switching valve with up to ten different ports. One is reserved for rinse water while the remaining nine ports are connected to different sources such as various sample streams. The TitraValve is a valuable component of the TitraSip SA system when employing the automatic sampling feature, as it provides the capability to switch between different sampling streams without the addition of extra pumps. It can also be used to dispense calibrants or quality control standards, or it can provide multiple titrant delivery with the use of only one buret drive. The TitraValve ensures the system is compact, fully automated and still affordable.

An autosampler allows for the analysis of field samples in addition to the regular monitoring of process streams, all utilizing the same platform. Various sizes are available, with the largest containing up to 197 sample positions. An autosampler will also be useful as part of the emergency response procedure. In the case of a contamination, an alarm can be triggered to warn of a potential hazard and the system will automatically grab aliquots of these suspect samples and dispense them into separate containers on the autosampler bed for further analyses. An operator simply collects these samples and analyzes them via Gas Chromatography, High Performance Liquid Chromatography and other laboratory instruments.

Software

The TitraSip SA is designed to run independently with continuous monitoring. This is achieved through an intelligent software feature in which the operator specifies the exact timing of the sampling. Depending on how many parameters are being analyzed, the system is programmed to draw sample as often as desired. A template is created by selecting pre-programmed analysis methods which include sampling and analysis functions. The operator then specifies the exact date and time that the methods will analyze at. As an example, the operator may specify that the analysis for conductivity, pH, alkalinity, turbidity and residual chlorine occurs every 20 minutes. Once the template has been created, a simple click on the "Start" button starts the continuous monitoring, and the TitraSip SA is left unattended. Since it does not rely on manual sample collection, this allows for continuous monitoring ensuring early detection of possible contaminants.

To further increase the automation of the TitraSip SA system, the SmartCal can be added, which includes automatic prescheduled calibrations. Quality control standards can also be analyzed automatically at user-specified intervals. All data generated, whether it is a calibration, a quality control check standard or a sample result, is recorded within the software. Customized reports can be set up to print out and/or be exported, simultaneously, to an external location at specific intervals. In the case of a calibration or quality control failure or a more serious breach of limits during sample analysis, an alarm system can be activated to notify the operator promptly. This includes a simple message on the screen or a more intricate series of events including flashing lights and alarm bells. The prompt notification of a possible contamination event allows operators to take immediate action.

RESULTS

Extensive testing has been completed using the Man-Tech automated systems for various water quality parameters at varying concentrations. A selection of data is presented in this section.

pH

Accurate monitoring of pH is essential. Changes in the pH of natural fresh water sources are usually caused by pollution, but higher pH values may also be caused by carbon dioxide from the air dissolving to become bicarbonates and carbonates in solution, or by alkali and alkaline earth metals in the ground. Quality control charts and statistical data are presented below.

Table 1: Statistical data for pH Buffers analyzed on the Man-Tech Automated Titration System

Standard Value	RSD
pH 4 buffer	+/- 0.002
pH 7 buffer	+/- 0.0007
pH 10 buffer	+/- 0.0006

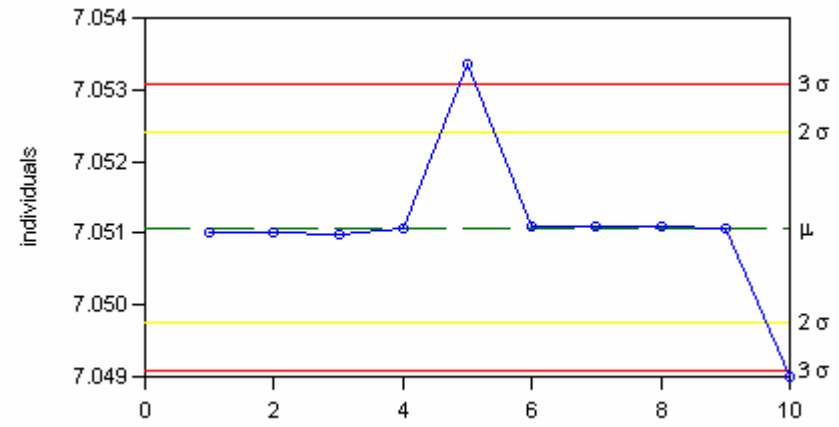

Figure 3: Control Limits Plot for a pH 7 Buffer Analyzed on the Man-Tech Automated Titration System

Alkalinity

Alkalinity refers to the acid-neutralizing or buffering capacity of a solution. The properties of water are easily influenced by the presence of alkalinity; therefore it is often used to monitor various types of water, including drinking water. Quality control charts and statistical data are displayed below.

Table 2: Statistical data for various alkalinity standards analyzed on the Man-Tech Automated Titration System

Standard Value	% RSD
1ppm	6.49%
10ppm	0.96%
200ppm	0.48%
500ppm	0.51%

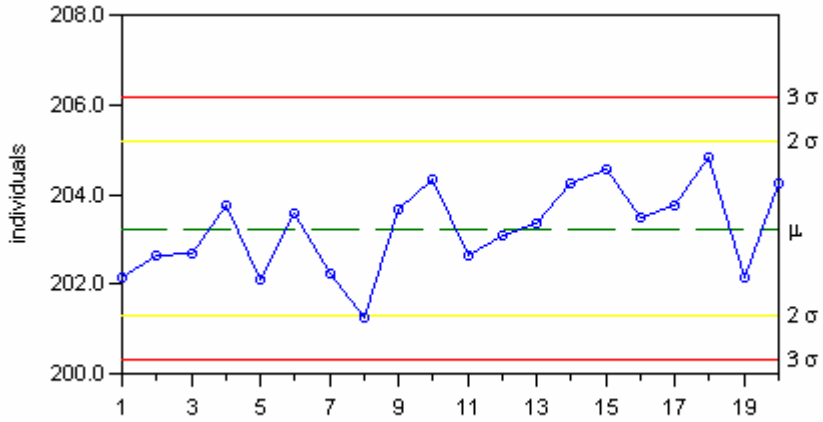

Figure 4: Quality Control Limits Plot for a 200ppm Alkalinity Standard Analyzed on the Man-Tech Automated Titration System

Conductivity

Conductivity is an excellent indicator of water purity and is used in the determination of water contamination. Conductivity may also be used to estimate the total dissolved solids (TDS) and the salinity of a sample. Quality control charts and statistical data are presented below.

Table 3: Statistical data for various conductivity standards analyzed on the Man-Tech Automated Titration System

Standard Value	% RSD
147uS	0.70%
1413uS	0.18%

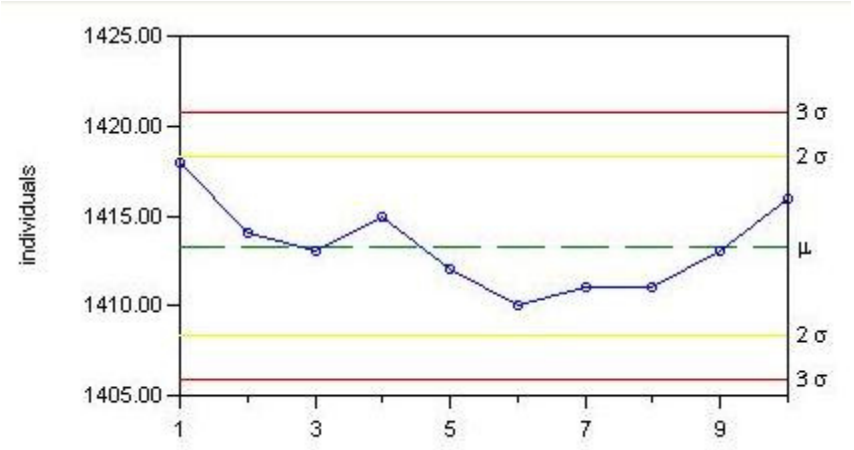

Figure 5: Control Limits Plot for a 1413uS Conductivity Standard Analyzed on the Man-Tech Automated Titration System

Turbidity

Turbidity is used as a general indicator of water quality, along with color and odor. A high turbidity indicates a large quantity of suspended particles, which in drinking water is undesirable as it causes an unpleasant taste and appearance as well as reducing the ability of chemicals and radiation to neutralize disease-causing bacteria and viruses. Quality control charts and statistical data are presented below.

Table 4: Statistical data for various turbidity standards analyzed on the Man-Tech Automated Titration System

Standard Value	% RSD
0.15NTU	10.1%
0.5NTU	3.75%
1NTU	2.95%
10NTU	0.73%
100NTU	0.19%

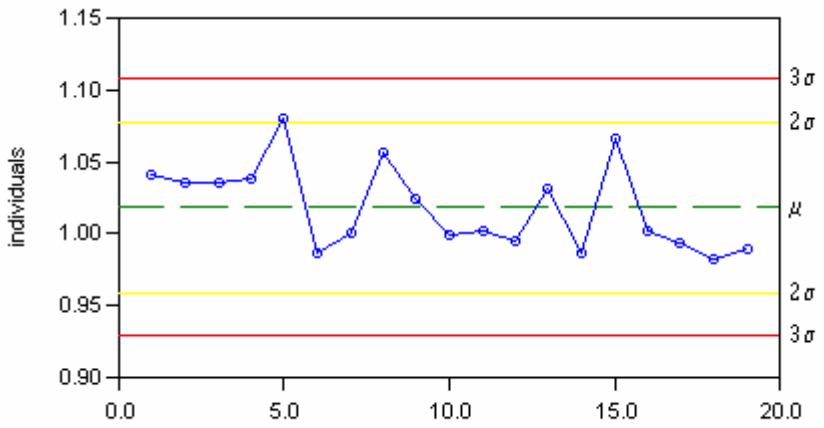

Figure 6: Control Limits Plot for a 1 NTU Turbidity Standard Analyzed on the Man-Tech Automated Titration System

CONCLUSIONS

The Man-Tech TitraSip SA system is ideally suited for continuous water quality monitoring, laboratory analyses and manual grab sample analyses. Multiple parameters are analyzed following EPA-Approved methods, the TitraSip SA operates unattended, and automatic sampling is available for both routine monitoring and in response to a triggered event. The continuous compliance monitoring made available by the TitraSip SA system provides early detection of a contamination event, therefore the appropriate emergency response measures are taken to avoid or minimize any potential threat to public health safety.

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