



Technical Report: TR02.1

Automated Monitoring and Dosage of Polymer Coagulants in Stormwater Treatment using a Streaming Current Detector

Introduction

Stormwater treatment systems are increasingly using polymer coagulants or flocculants. Polymers offer significant improvements in clarification efficiency and effluent water quality, at relatively low cost. However, they require precise and accurate dosage control for optimum efficiency and to minimize polymer consumption, and, most importantly, to eliminate potential toxicity to receiving waters.

To date most polymer treatment systems have used equipment in which the polymer dose is controlled using a metering pump coupled with an influent flow meter. The optimum dose is determined by a series of jar tests, and a metering pump is set to feed polymer into the influent water at the target dose. The polymer feed rate is coupled to overall flow rate to give a constant dose as system flow varies. Dose monitoring is normally done using an indirect method such as effluent turbidity measurements or residual polymer analysis. While these control systems are effective, they have potential limitations. Most important is that due to variation in suspended sediment levels, which can vary dramatically during storm events, a new optimum polymer dose must often be determined and quickly applied, often under less than ideal circumstances. The Streaming Current Detector offers a method to automate polymer dosage for optimum water quality and minimum polymer consumption, under continually or rapidly changing conditions.

The Streaming Current Detector

ProTech has developed a polymer dosage control and monitoring system based on a Streaming Current Detector (SCD) that provides substantially better polymer dose control than previous methods. While SCDs have long been used in water and wastewater treatment plants, they have not been used in stormwater treatment systems until now. The SCD provides accurate and precise polymer dose, as well as acting as an automatic dose monitoring and verification system. The SCD will work with any polymer coagulant or flocculant, or combination thereof that operates by charge neutralization.

The SCD measures an electric current which is the net (both positive and negative) ionic and colloidal surface charge of a water sample. In an SCD water flows into a chamber by the action of a reciprocating piston. The movement of the water between two electrodes in the chamber creates an electric current that is proportional to the net charge of the sample. This current is defined as the streaming current, which is electronically amplified and routed to the control circuitry. The measurement, known as the SC value, is measured in SC Units or SCU, and is normally displayed in a range of -10.00 to + 10.00.

Polymer coagulation functions by neutralizing the surface or ionic charge of suspended particles, which reduces the repulsive forces between particles, encouraging agglomeration and sedimentation. Therefore, the charge measured by the SCD is a direct measurement of the efficiency of particle coagulation/flocculation.

The streaming current is directly related to the more familiar zeta potential measurement of particle surface charge, according to the formula:

$$i = ZD/N$$

(where i = streaming current, Z = zeta potential, D = dielectric constant, and N = viscosity).

Streaming current is therefore another method to measure zeta potential, but the numerical values are not equivalent. A zeta potential of -10 MV, for instance, is not -10 SC units. The absolute SCU value is also not generally equivalent to polymer concentration. The SCU value can be correlated to a specific concentration, but must be done on the project-specific basis, for specific polymer and water chemistry.

In operation the SCD is calibrated using an empirically determined optimum polymer dose with the stormwater to be treated. Depending on the particular instrument, a separate calibration standard may also be used. With the SCD calibrated, it is usually unnecessary to perform jar tests during operation, though they may be conducted for QA/QC purposes.

The SCD in a Stormwater Treatment System

A typical ProTech stormwater treatment system consists of an influent pump, polymer coagulation unit, clarifier tanks, sand filters, cartridge and/or membrane filter, and a control system. The SCD-based polymer coagulation unit uses an SCD in conjunction with a flow meter, polymer metering pump, on-line turbidity meter, and controller processor and software. In operation the SCD measures the net charge downstream of the polymer injection point, sending the measurement to the controller.

The SCD is calibrated and correlated to the optimum dose. The controller calculates a target polymer dose based on the SCD measurement and an internal algorithm. As flow and suspended material load varies, the system continuously recalculates dose to maintain optimum and varies polymer feed accordingly. Optimum polymer dose is reestablished within minutes of changes in flow or suspended materials. The SCD, controller, and metering pump provide a feedback system assuring continuous, accurate polymer dosage.

The SCD controller maintains the target dose by a “set point”, which is the SCU value that corresponds to the optimum dose, typically determined by jar tests. In operation, the set point can be adjusted upwards or downwards, allowing the system to be fine tuned for specific conditions or requirements. Figure 1 below illustrates the relationship between polymer dose, SCU measurement, and turbidity for a typical system. The data for Figure 1 was collected from a working system during the 2004/2005 season.

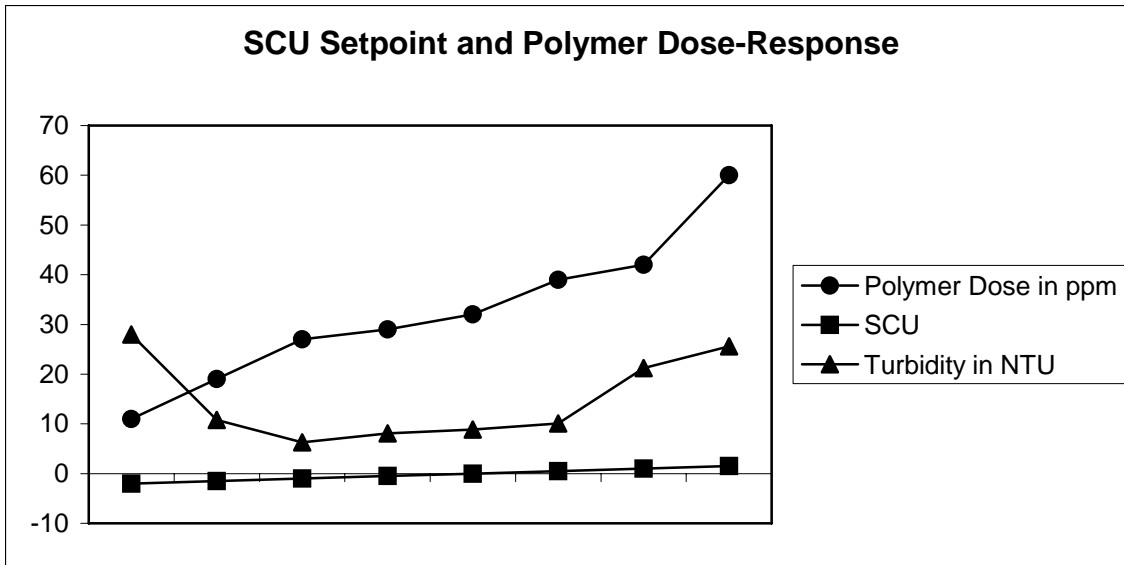


Figure 1. Relationship Between Polymer Dose/Response and Streaming Current Detector Set Point.

Figure 1 shows that by varying the set point the system can be programmed to meet specific requirements. For example, say that a system set point is initially -1.0 SCU, which results in polymer dose of 27 ppm and a turbidity of 6 NTU. Resetting the set point at -1.5 results in a polymer dose of 19 ppm and a turbidity of 10 NTU. This corresponds to a 30% reduction in polymer consumption, while yielding 10 NTU effluent.

The SCD measurement point is located at a point downstream of the polymer injection where mixing and charge neutralization is complete. If neutralization has not progressed sufficiently, the SCD will oscillate around the optimum value as the controller alternately overdoses and underdoses polymer.

SCD measurements are taken approximately 15 seconds downstream from the polymer injection point, and there are time lags unique to each system due to variations in system layout and piping. The SCD controller software includes an integrating algorithm that is programmed to incorporate these variables in dose calculations. Correctly incorporating the relationships between mixing time (between polymer injection and the SCD measurement point), system time lags, and optimum coagulation into the controller programming software are the critical elements to maintaining a stable operating system.

In operation, complete ProTech treatment systems typically have a residence time of 1-2 hours, which ensures complete neutralization as well as sufficient time for gravity settling and sedimentation. Furthermore, although the SCD system optimizes polymer dose with a sensitivity of less than one ppm, polymer coagulation is a robust process and is not compromised even by significant variation in dose. ProTech's performance and toxicity testing (ProTech Services Technical Report, Polymer Coagulants and Flocculants, July 2004) has demonstrated that the system performance, in terms of effluent water quality and environmental protection, is not compromised even with polymer doses at 2X optimum. The SCD therefore provides a wide margin of safety.

A properly installed and calibrated SCD provides the most accurate and precise method of polymer control available. By continually compensating for changing flow and suspended sediment loads, it eliminates the possibility of polymer overdosing and potential toxic effects to receiving waters. The system includes comprehensive data storage and reporting capabilities, including the ability to automatically send data reports by cell phone or email with an appropriate data link. The controller includes additional input ports that allow the system to incorporate real-time pH or other measurements. The polymer feed and SCD control unit itself is compact and requires little electrical power, and can be operated with a small generator or solar array.

SCD System Performance

ProTech operated SCD systems at several projects during the 2004/2005 season, including sites with stormwater exceeding 1,000 NTU, during rainfall events with almost two inches precipitation in six hours. Figures 2 and 3 show the typical SCU measurement and corresponding polymer dose over an approximately 15-hour period. The system takes a measurement every 3 seconds, but for these illustrations Figure 2 shows hourly measurements and Figure 3 shows measurements on 10-minute intervals.

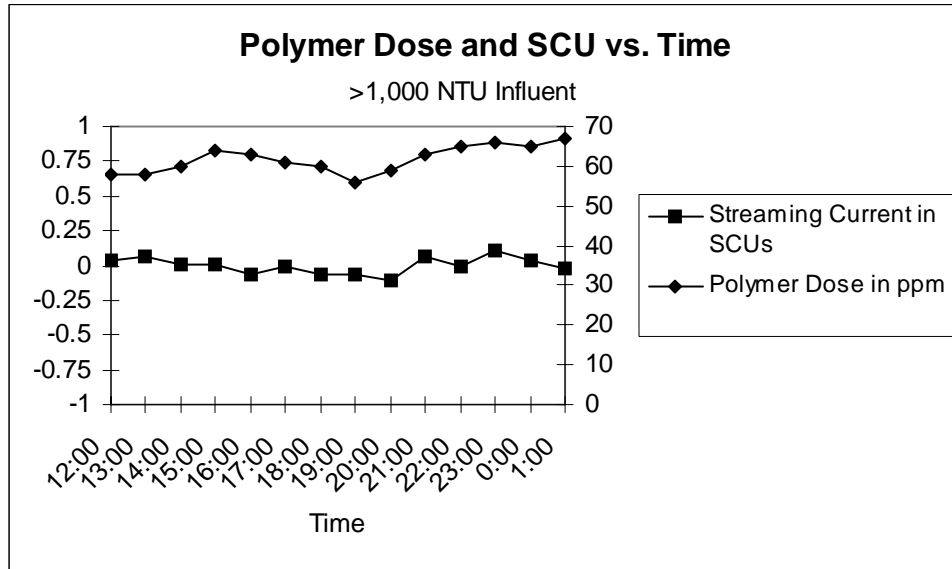


Figure 2. Polymer Dose and SCD measurement on hourly intervals.

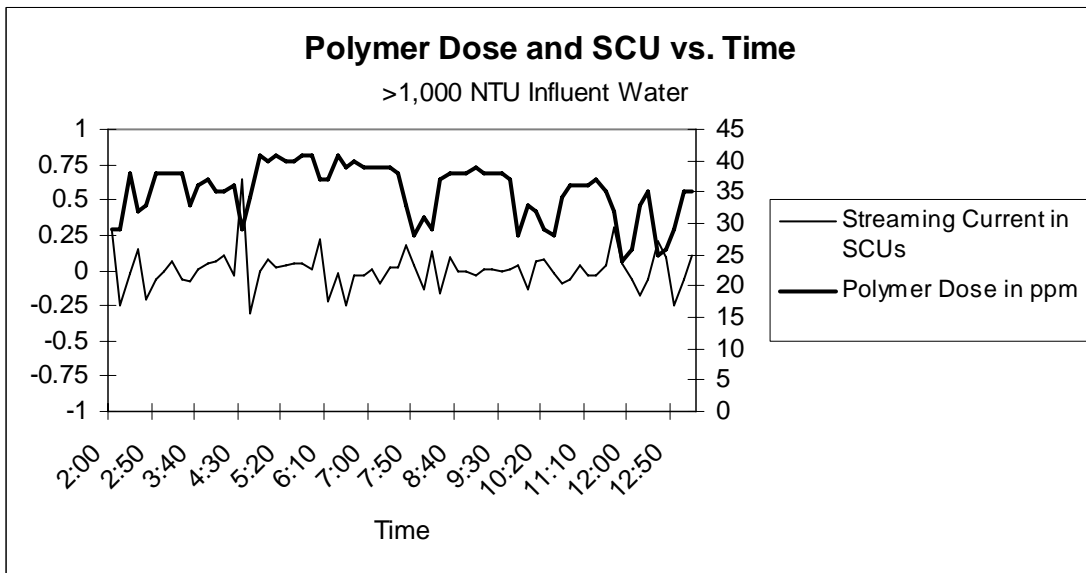


Figure 3. Polymer Dose and SCD measurements on 10-minute intervals.

Figure 2, with data collected hourly, shows a stable operating system, typically fluctuating a few hundredths of an SCU around zero, reflecting the slight charge variation that signals the controller to adjust polymer dose. Figure 3, with data collected on 10-minute intervals, shows how rapidly that polymer dose is adjusted as the SCU measurement varies. Effluent turbidity for both systems was consistently measured at less than 10 NTU.

A properly calibrated SCD system will respond to large changes in influent water within minutes. This level of dosage control is not possible with systems relying on jar tests and flow proportional polymer metering. Storm events and changing influent turbidity are effectively transparent to the stormwater treatment system, due to the SCD's rapid response to changing influent characteristics. Additionally the controller programming allows fine tuning of the polymer dose to minimize polymer dose and consumption while maintaining effluent water quality (as shown in Figure 1), with a much greater sensitivity than possible using jar test data.

Polymer Consumption

By optimizing polymer dose as conditions and water quality changes, the SCD minimizes polymer consumption. The polymer dose and consumption rate will vary, depending on flow rate, turbidity and other water characteristics, and polymer type. Figures 4 and 5 show polymer consumption at two typical project sites. Both were 500 gpm systems, with influent water that exceeded 1,000 NTU.

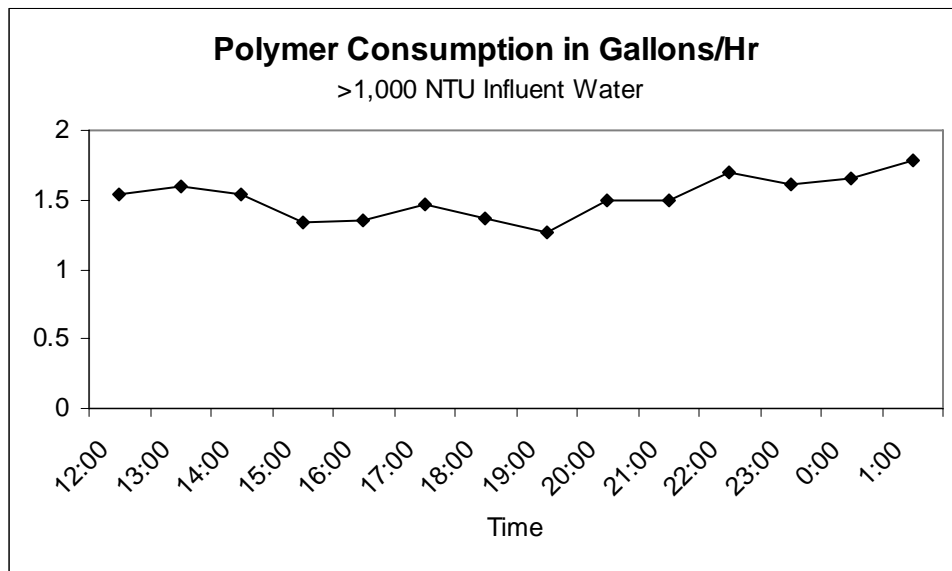


Figure 4. Polymer Consumption vs.Time.

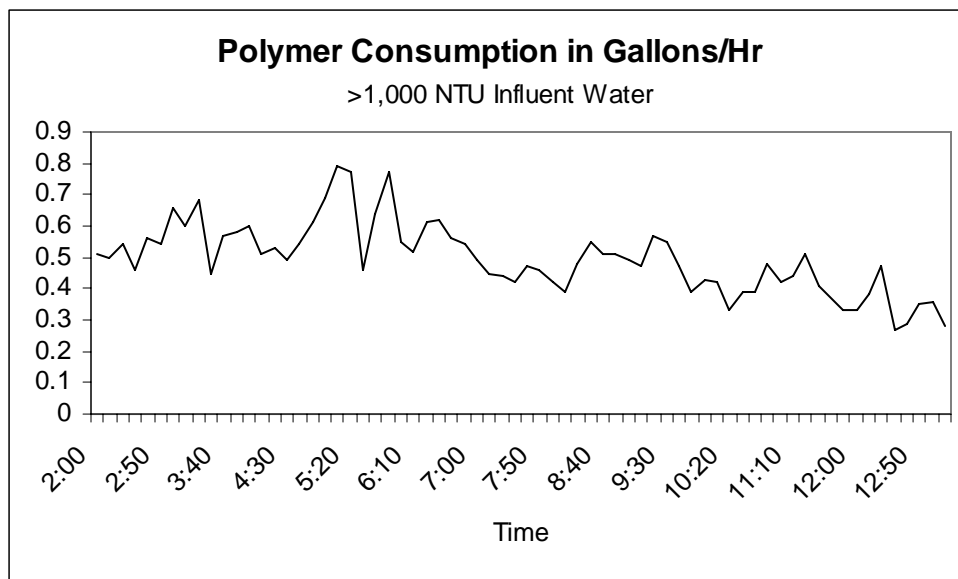


Figure 5. Polymer Consumption vs. Time

In Figure 4, which is for a particularly difficult to treat stormwater, polymer consumption varied from 1.2 to 1.7 gallons polymer per hour, or about 45 gallons polymer per 1,000,000 gallons of water treated. In Figure 5, which is more typical of stormwater in the Sacramento California area, polymer consumption varied from 0.3 to 0.8 gallons per hour, or about 15 gallons polymer per 1,000,000 gallons of water treated.

Conclusions

The Streaming Current Detector is the best available method to control polymer dosage in a stormwater coagulation system, even under rapidly changing storm conditions. By continually monitoring the ionic charge and coagulation efficiency of the system, effluent water quality is optimized and polymer use is minimized. Operational costs are reduced and risk of overdose or upset is virtually eliminated, providing maximum environmental protection with a wide margin of safety.