

OPERATIONS MANUAL

Coagulant Charge Analyzer

CCA 3100 **Laboratory Model**

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Chemtrac[®] Systems, Inc.

6991 Peachtree Industrial Blvd. • Building 600 • Norcross, GA 30092
(800) 442-8722 • PH (770) 449-6233 • FX (770) 447-0889
chemtrac@chemtrac.com • www.chemtrac.com

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SYMBOL KEY



Risk of Electric Shock



Note



SAFETY PRECAUTIONS



BEFORE ATTEMPTING TO UNPACK, SET UP, OR OPERATE THIS INSTRUMENT, PLEASE READ THIS ENTIRE MANUAL.

MAKE CERTAIN THE UNIT IS DISCONNECTED FROM THE POWER SOURCE BEFORE ATTEMPTING TO SERVICE OR REMOVE ANY COMPONENT.

FAILURE TO FOLLOW THESE PRECAUTIONS COULD RESULT IN PERSONAL INJURY OR DAMAGE TO THE EQUIPMENT.



WARRANTY INFORMATION



Warranty: Chemtrac[®] Systems, Inc. warrants its product to be free of defects in material and workmanship for a period of one (1) year from date of shipment to the original customer.

Upon receipt of written notice from the customer, Chemtrac[®] Systems, Inc. shall repair or replace (at the discretion of Chemtrac[®] Systems, Inc.) the defective equipment or components.

Chemtrac[®] Systems, Inc. assumes no responsibility for equipment damage or failure caused by:

- A. Improper installation, operation, or maintenance of the equipment.
- B. Abnormal wear and tear on moving parts caused by some processes.
- C. Acts of nature (i.e. lightning, flooding, etc.)

This warranty represents the exclusive remedy of damage or failure of the equipment. Under no circumstances shall Chemtrac[®] Systems, Inc. be liable for any special, incidental, or consequential damage, such as loss of production, profits or product quality. The warranty cannot be guaranteed if the customer fails to service and maintain the equipment in accordance with Chemtrac[®] System's written instructions and policies, as stated in the Operations Manual.

1.0 COAGULANT CHARGE ANALYSIS

1.1 INTRODUCTION

The Coagulant Charge Analyzer (CCA) can provide valuable data concerning charge demand and coagulation for water treatment systems. The CCA's output is the **STREAMING CURRENT VALUE (SCV)**, a term which is commonly interchanged with “charge” or “charge measurement.” A voltage and current is generated by electrically charged particles in the sample that are momentarily attached to the cylinder walls within the probe. A reciprocating piston causes fluid motion, which shears the loosely bound counter-ions away from the particles attached to the cylinder walls. Electrodes in the cylinder measure this current generated by the sheared counter-ions. The signal is electronically processed and the output is the SCV.

The loosely bound counter-ions, mentioned above, are a component of the “double layer.” This concept is described in Section 1.3. Both streaming current and zeta potential are based upon the double layer principle. Therefore, the streaming current value produced by the CCA is comparable to the well known zeta potential.

1.2 BACKGROUND

As originally developed, the streaming potential measurement utilized a capillary passage or porous plug of the material of concern, through which the bulk fluid can be forced by an applied pressure. Counter-ions in the diffuse layer surrounding the material then migrate with the fluid, creating an electrical potential or current, either of which can be measured. If the current is measured, it is termed the “streaming current.” The CCA 3100 measures the streaming current without the need for a capillary passage or porous plug. Rather, the

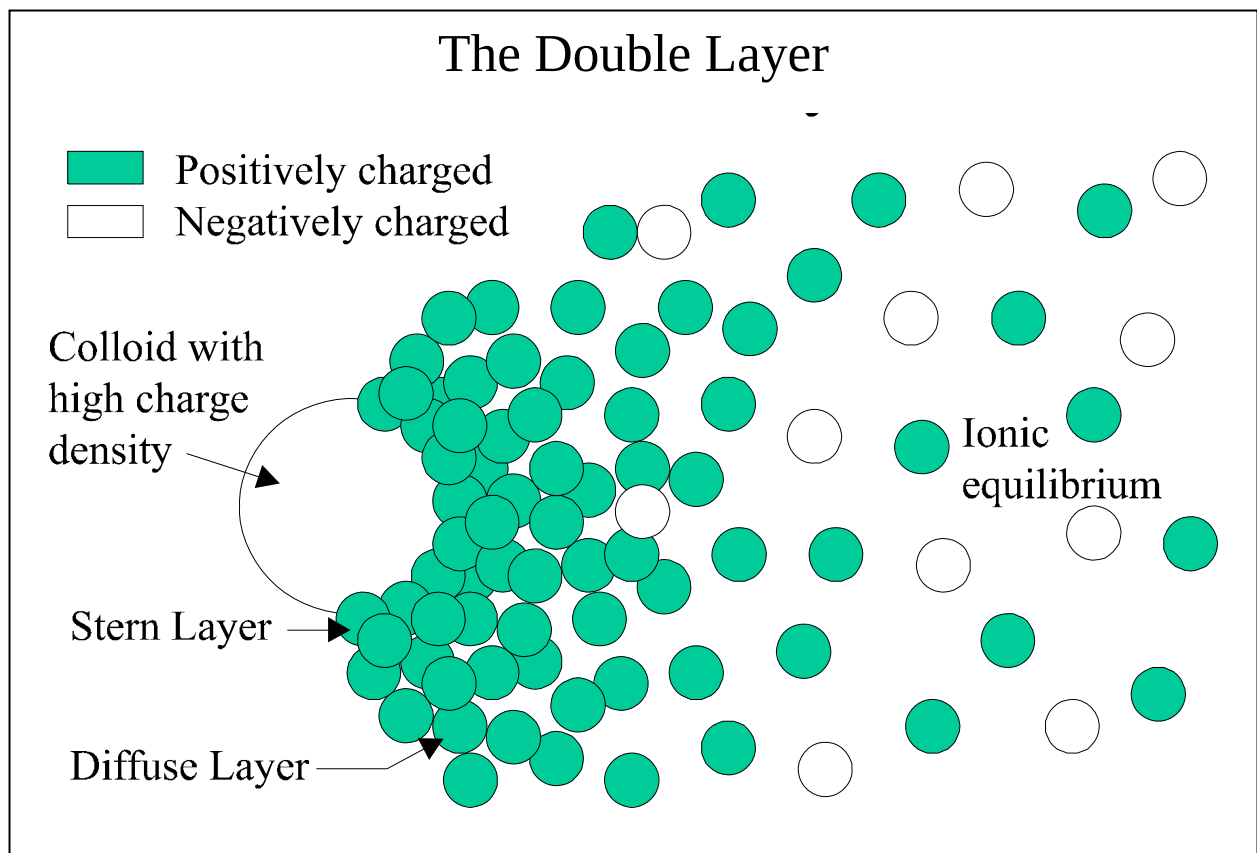
laboratory unit employs a piston and probe assembly, which is completely described in the following sections.

1.3 STREAMING CURRENT AND THE DOUBLE LAYER

Surface chemistry and physics are important to water treatment chemistry and the destabilization of colloidal particles that naturally occur in water. One branch of surface chemistry is colloidal chemistry, which is the study of a stable combination of particles that are dissolved or suspended in a second substance. Two important aspects of colloidal chemistry are the particle sizes (on the order of microns) and the net charge of these particles. Because of their small size, surface area plays a major role in their behavior, along with the charge density associated with each particle.

One goal of coagulation and flocculation is to reduce suspended particles (turbidity) that if otherwise left untreated would negatively impact drinking water quality either by aesthetical, chemical, or microbiological contamination. Generally, naturally occurring particles carry a net negative charge in raw water. Positively charged coagulants are effective in aggregating the smaller particles into larger, more filterable, particles through collisions brought about by mixing with raw water. The cationic floc particles formed during coagulation react with the surface of the anionic colloid to destabilize its charge structure. The Diffuse layer, or the outer layer of the colloid, holds ions that are spaced further apart and can be displaced when a shear force is applied. The CCA effects the shearing of counter-ions, and then measures the current generated by the movement of these cationic particles. This is how the streaming current value is measured by the CCA

FIGURE 1



2.0 SPECIFICATIONS AND COMPONENTS

2.1 SPECIFICATIONS

Dimensions 8"W x 8½"D x 21"H

Weight 14 lbs. (6.36 kg)



Power Requirements

115VAC, 50/60Hz, 410 mA
Optional 220VAC, 50/60Hz, 205 mA

Environmental Temperature 15-45°C

Enclosure Aluminum



Information Derived

Streaming Current in mV

Measured Parameter Streaming Current

Sample Aqueous process material less than 0.2% consistency



Output Signals

RS-232/485 (Serial Port)

Materials in contact with sample Delrin, Teflon

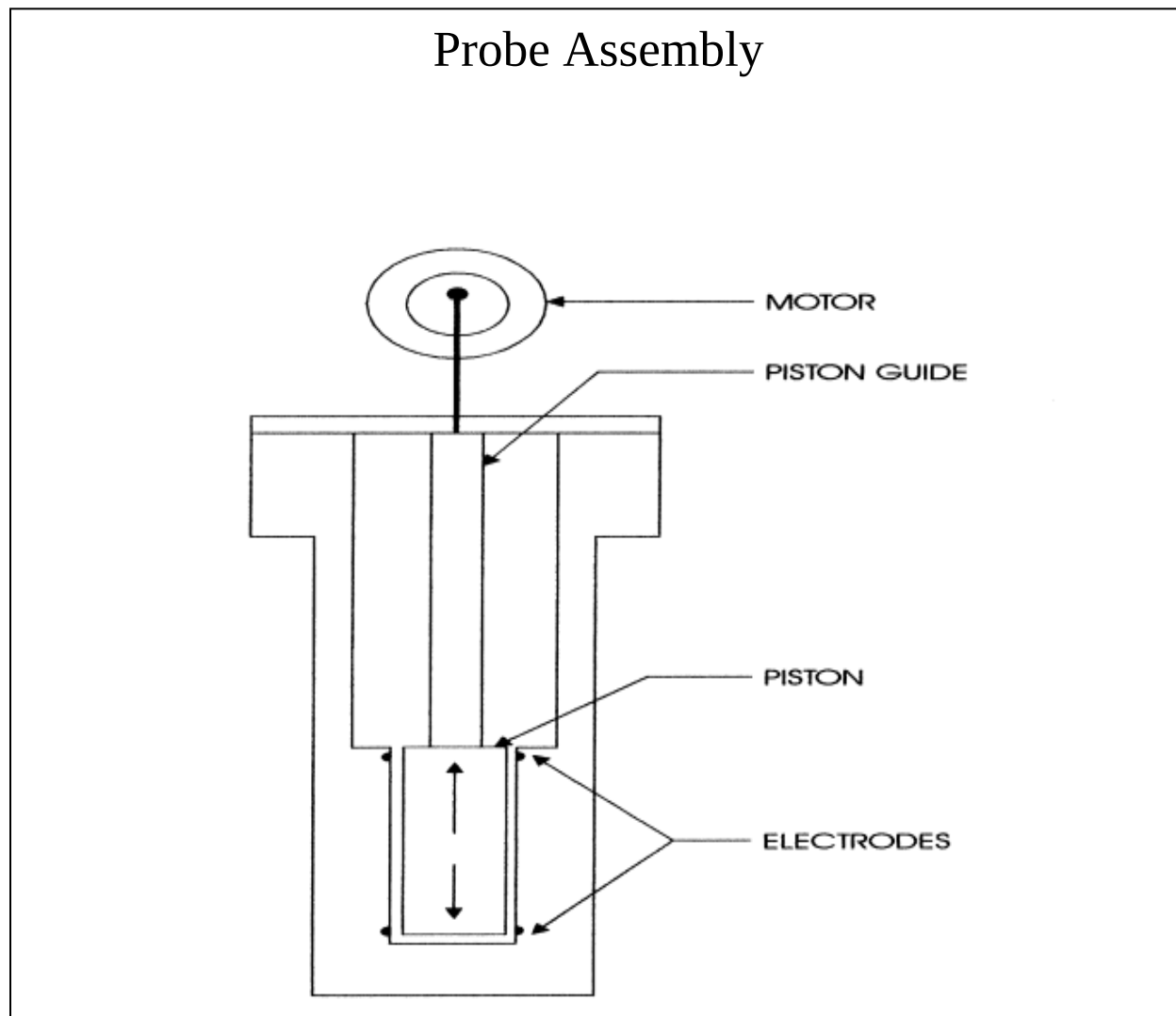
2.2 PROBE ASSEMBLY

The CCA consists of a probe assembly and a signal processor. The probe assembly is comprised of the piston and sensor, which houses the electrodes that measure the streaming current. The signal processor is the circuit board inside the CCA.

A simplified picture of the probe assembly is presented in Figure 2. The sample, which contains the water to be characterized, flows into the cylinder (via side holes that are not shown.) Inside the cylinder is a small piston that reciprocates vertically. Above the piston, the piston rod is attached to an eccentric point on a crank driven by a motor. The piston's velocity is thus sinusoidal in nature.

The piston moves up and down inside a cylinder that is closed at the bottom. The space between this piston and the cylinder is called the annulus, which is critical to the streaming current device. The annulus has the shape of a thin, cylindrical "shell," which contains sample fluid and particles. The clearance between the piston and cylinder walls is several thousandths of an inch (in metric units, on the order of hundreds of microns.) As the piston reciprocates, it acts as a pump: when moving downward, it forces sample out of the cylinder, upward through the annulus. Note that the annular clearance is large enough to allow most particles in a typical sample to pass in or out, but small enough to cause significant fluid velocity within this space. After the piston reaches its downward position, it precedes upward, pulling fluid downward into the increasing volume below this piston. All directions are thus reversed in this stage of the piston's travel. The constantly reciprocating piston ensures continuous renewal of sample, such that changes in particle characteristics can be monitored.

FIGURE 2



It may then be assumed that the surfaces of both the piston and cylinder become adsorbed or coated with particles from the sample. (There are other ways of viewing this phenomenon, but this assumption provides a workable explanation.) These particles, namely the anionic species, adhere to the piston and cylinder walls by Van der Waal's forces. As fluid motion is induced by the reciprocating piston, the counter-ions of the double layer are sheared away from the colloidal particle.

Figure 2 shows where the electrodes are positioned in the CCA's sensor. These are two metal rings inserted in upper and lower areas of the cylinder. If the piston is moving downward (and, therefore, the fluid motion is upwards), and the attached particles are negatively charged (and,

therefore, the outer charged layer is positive), then according to convention the electrical current is traveling from the lower to the upper electrode.



It should be clear that the STREAMING CURRENT VALUE is dependent on the fluid direction and velocity. (Of course, the fluid velocity is dependent upon the size of the annulus.) The resulting signal is an alternating current, which can be separated easily from constant background effects. The magnitude of the charge density determines the magnitude of the streaming current at any point, and thus determines the amplitude (peak height) of the alternating current signal.

2.3 SIGNAL PROCESSING

The processing of this alternating current is the other important aspect of a CCA. The current generated in the sensor is on the order of 10-12 microamps, which is extremely low, and a sensitive amplifier must be used. In order to measure the signal, the amplifier must be low impedance because, in its absence, the circuit would be completed by conductance back through the liquid. Essentially, the amplifier must have a lower conductance than the sample in order to



complete the circuit and measure the current. Hence, conductivity above 3,000 μS will begin to dampen the signal and may eventually render the SCV useless.

Figure 3 shows the stages involved in processing the streaming current signal. As indicated, the current generated at the sensor is directly proportional to the piston velocity, provided that the particle characteristics are not changing over this time frame. The circuitry must change this signal into a constant, readable value that is proportional to the amplitude (height) of the original sensor output. This is accomplished by rectifying the entire signal. The signal is simply changed to a positive value whenever it is negative. Finally, the signal is filtered, or “time-smoothed,” to give a continuous and consistent reading.

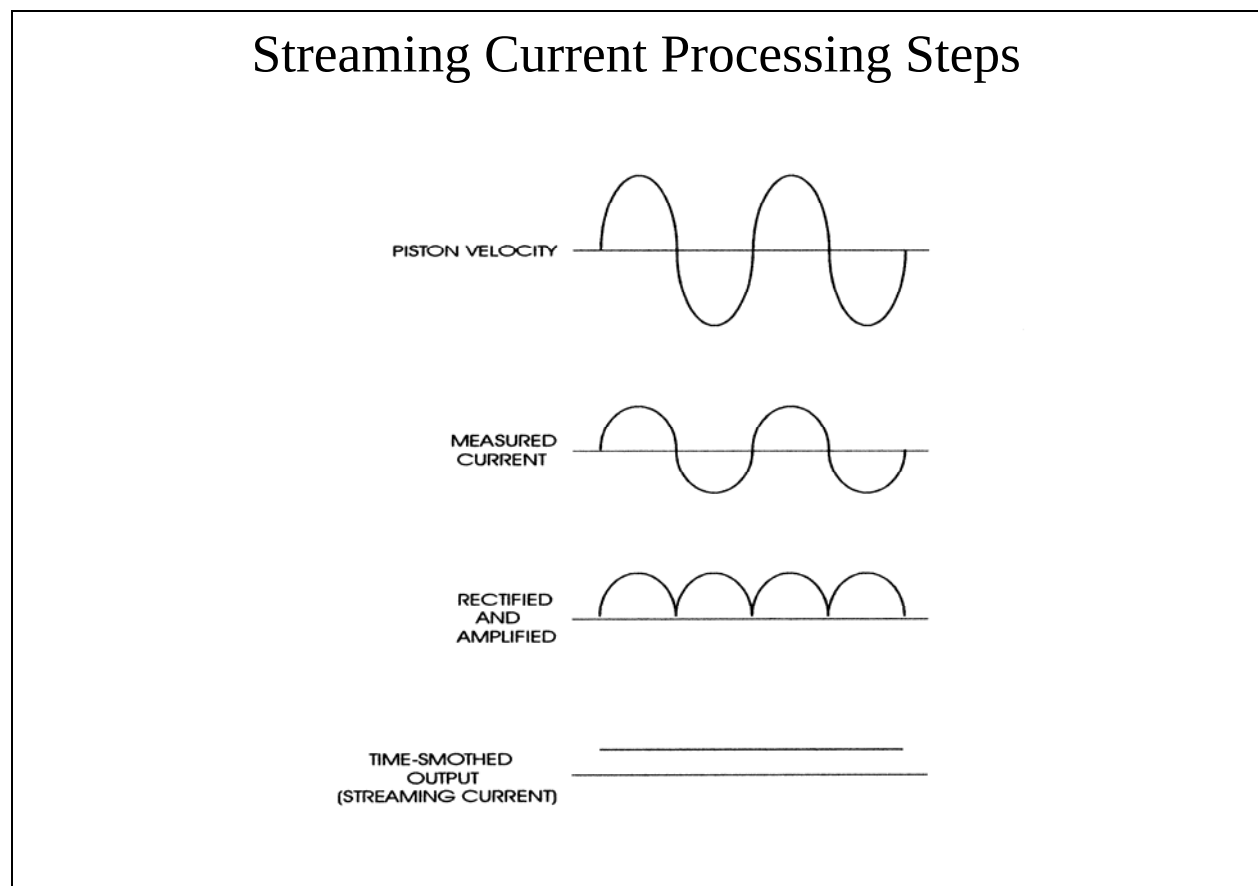


The value of this “streaming current” is in relative units. The instrument is not calibrated to be numerically equal to the actual current or charge density that exists in the sensor, primarily because the calibration would be sensitive to small differences in the physical dimension of the

annulus. Another reason the instrument is not calibrated to display a discrete charge value is that the instrument is sensitive to differences in charge distributions that vary from simple systems to complex systems. However, the unit includes a sensitivity adjustment (HI or LOW) that amplifies the original signal activated by the switch located on the face plate.

Figure 3 also suggests how the processing of an alternating current signal from the sensor serves to eliminate any extraneous currents. Suppose the entire signal is moved upward a certain amount due to an interfering current which is constant in value. When the signal is rectified, the positive peaks remain at a higher level, but the negative peaks are at a lower level when they are “flipped” to the positive side. After this rectified signal is smoothed, the overall result is to eliminate the interference, since half of the peaks were too high and half were too low.

FIGURE 3



3.0 OPERATION



The CCA 3100 offers two power switches. The first is located below the face plate and supplies power to motor that drives the piston. The second power switch is located on the back of the unit near the power cord connection. The switch in back allows the operator to turn the power off entirely to the unit.

The small switch located on the face plate controls the gain for signal boosting.

3.1 SENSOR AND PISTON

The sensor and piston are critical components of the CCA 3100 that require care and regular cleaning.

3.1.1 Removal

1. Turn the motor “Off.”
2. Loosen the thumbscrew on the lower portion of the sensor.
3. Secure the CCA with one hand and with the other, pull down on the lower portion of the sensor to disconnect at the banana plugs.
4. To remove the piston, unscrew by hand or, if necessary, with a flat blade



screwdriver. Hand-tight is sufficient to secure the piston.

3.1.2 Insertion

1. Turn the CCA “Off.”
2. Screw the piston on by hand, taking care not to damage the threads.



Hand-tight is sufficient to secure the piston.

3. Position the sensor so that the thumbscrew is facing forward.
4. Secure the CCA with one hand, and then insert the sensor by aligning the banana plugs. The sensor will rest “flush” against the main body of the CCA so that the

banana plugs are no longer visible. This will ensure a good electrical connection and prevent fouling of the connections.

5. Tighten the thumbscrew to secure sensor.

3.1.3 Standard Cleaning Procedure

With some particles, cleaning is easily accomplished by rinsing with tap water. Others (especially cationic particles) are tenacious and must be removed with fairly vigorous cleaning. The following cleaning procedure will assure that the CCA is providing accurate, reproducible measurements.

1. Remove the sensor and piston according to the procedure outlined above. Remove the plug and O-ring from the bottom of the sensor.
2. Scrub the surface of the piston and cylinder, (both inside and outside) with a stiff nylon test tube brush and a mild abrasive cleanser (e.g. Comet). Use room temperature tap water.



Avoid water contact with the banana plugs.

3. Rinse all of the surfaces thoroughly with tap water, ensuring that they are free of soap film and any residue. Carefully inspect the inner surface of the cylinder to ensure that no visible particulate matter is left on the surfaces.
4. Completely dry the sensor, piston and plug with compressed instrument air or by allowing the components to air-dry in the laboratory.
5. Return the plug and O-ring to the base of the sensor. Omitting the O-ring will cause variations in the SCV.



Distilled or de-ionized water may be used. However, the water's low conductivity will magnify the SCV. Thus, the operator must ensure that all surfaces are completely dry before use.

4.0 PRACTICAL CHARGE MEASUREMENT

This section provides the operator of the CCA 3100 with practical guidelines for obtaining reliable data. It is the responsibility of the operator to determine the appropriate application for charge measurement, consistently follow the procedures described in this manual, and then determine the meaning of the data.

4.1 CONDITIONING



Chemtrac recommends that the sensor and piston be conditioned before the actual charge measurement is performed. Conditioning will replace foreign molecules with ones that are similar to the sample being tested. Additionally, one may consider that conditioning will “coat” the surfaces of the sensor and piston with the sample to be tested.

To condition the sensor, simply run a couple of charge measurement analysis without cleaning the probe and piston with comet.

4.2 CHARGE MEASUREMENT



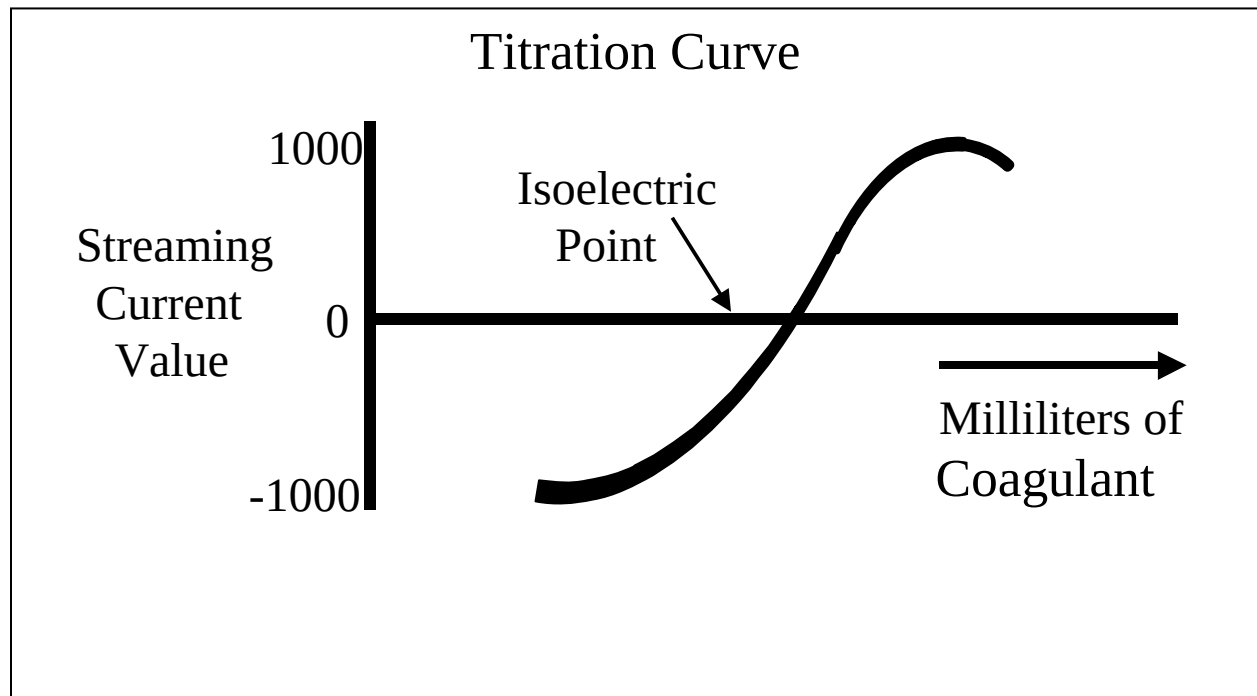
Remove the conditioning sample, and replace with the true sample. Follow the same steps as stated in the previous paragraph. After the SCV has stabilized, record this value.

4.3 CHARGE DEMAND (TITRATION)



To determine the charge demand of a sample, a coagulant of opposite charge is added until the isoelectric (0.00) point is achieved. The coagulant is made-up to a known concentration and referred to as the “titrant.” The CHARGE DEMAND refers to the amount of titrant, in milliliters, that is required to bring a sample to the isoelectric point. This is demonstrated in Figure 4, where a net anionic water sample is dosed with a coagulant until the isoelectric point is achieved and then surpassed.

FIGURE 4



Note that in Figure 4, the SCV tangentially approaches zero. This is critical to achieving a valid titration, and is achieved by an appropriate addition rate of titrant. A slow addition rate ensures that each molecule is given the opportunity to adsorb onto a colloid and stabilize itself to achieve its lowest energy level. A hasty titration will cause the SCV to overshoot the isoelectric point, giving a false CHARGE DEMAND.



This “overshoot” is depicted in Figure 4 but is not the normal procedure for a titration.

4.3.1 Charge Demand Procedure

Please read this procedure completely and thoroughly prior to starting the titration. Operators may make adjustment specific to their facility after determining how the CCA unit works.

Purpose:

The purpose of this procedure is to demonstrate how quickly the CCA can ballpark chemical dosages in place of routine jar tests. The CCA is quick and easy. Operators simply place a jar of raw water under the CCA, add the required chemical to control pH, and titrates the jar to neutral using coagulant. In less than two or three minutes, the operator knows approximately how much coagulant is needed to treat the water.

Jar testing requires the plant to measure several samples of raw water (usually one or two liters) into jar test beakers and place under a gang mixer, then dose the beakers at different chemical levels using alum, ferric, caustic, lime, soda ash, etc. Using the gang mixer, operators control the paddle speeds to simulate mixing conditions in the plant. After ten to fifteen minutes of mix time, operators may shortcut the normal test and visually determine which beaker gives the best floc formation. The plant's chemical feed pumps are adjusted to deliver the calculated dosage based on the plant raw water flow rate.

Stock solutions:

Make-up one percent chemical stock solutions for the jar test procedure. Each milliliter of stock solution is equivalent to 5 ppm chemical dose into 2000 mls of raw water.

To prepare a 1 percent solution of alum, simply weigh 1 gram of dry alum and dilute to 100 mls using distilled water (tap water contains chlorine which reacts with alum). One milliliter of this solution when added to one liter of raw water gives a dose of 10ppm or 10 mg/L. Using liquid Alum (50%), simply weigh 2 grams of liquid and dilute to 100mls.

Procedure:

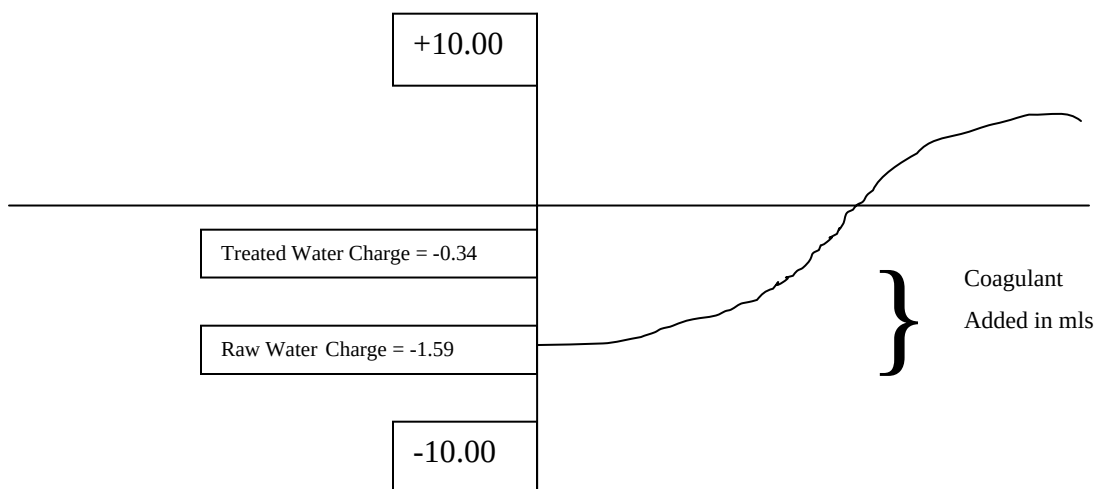
1. Add 2000 mls of raw water to a 2 L beaker.
2. Place the beaker under the CCA. Turn on the stirrer, the CCA and allow the unit to stabilize. Slow changes in the hundredths decimal place are acceptable.
3. Add pH control chemicals to the normal dosage rate used by the plant. Theoretically, a final pH of 6.5 to 6.8 is optimum for alum coagulation.
4. If the plant feeds polymer for pretreatment, add polymer to the beaker at the plant's normal dosage.
5. Add coagulant dropwise using a pipette or syringe with 0.1 accuracy and watch the streaming current value. When the streaming current value reaches zero, stop adding coagulant. The coagulant must be added away from the piston opening in the probe. Otherwise the coagulant will saturate the probe and drive the reading positive very quickly.
6. Record the number of mls used in the titration. Each ml is equal to 5 ppm.
7. **Discard the first sample.** The first sample is used to condition the probe and piston. It also informs the operator with the approximate endpoint for the titration.
8. Repeat steps 1-6 (do not wash the probe and piston) and record the mls of coagulant used.
9. To calculate the ppm of coagulant, multiple the number of mls in step 8 by 5.
10. Steps 1-6 should take less than 2 minutes to perform. Immediately place the beaker under the gang mixer at 40 rpms for 3 minutes. Then allow it to mix at 10 rpms for 10 minutes. Notes all parameters that you would record for jar testing including floc size, formation, settling, pH, and turbidity.

Compare your results to the actual chemical dosage being used by the plant. If your results are greater than +/- 10 percent, you may wish to proceed with the following steps.

4.3.2 Suggested Charge Measurement for Process Control:

1. Collect a sample from the flash mix – the chemical must be thoroughly mixed with the raw water prior to your sample point. Also, the plant must be producing good quality water as determined by turbidity, pH, alkalinity, etc. Measure 2000mls into a 2 L beaker and place under the CCA probe.
2. Turn on the stirrer, the CCA, and allow the unit to stabilize. Record the charge of the flash mix
3. Once the CCA stabilizes (this may take a minute or two, especially in cold water), begin the alum titration and continue until you reach the charge reading in step one.
4. Record the number of mls required. Calculate the amount of chemical you dosed by multiplying each milliliter by 5.
5. Compare your results to the plant's dosage calculations. Adjust chemical feed as necessary. The plant may wish to compare this charge value to the "best jar" based on routine jar testing. To compare, simply place the "best jar" under the CCA immediately after completing the CCA process control procedure.
6. The following figure illustrates the procedure:

FIGURE 5



4.4 APPLICATIONS

Effective utilization of the CCA 3100 is the responsibility of the operator. Ingenuity and creativity are required. Charge analysis can be utilized on the following sample locations:

1. Test the raw water to determine coagulant demand by titration.
2. After flash mix, measure charge to determine optimum chemical dosage
3. Compare a sample after the on-line unit with a charge measurement on the CCA to verify on-line operation and pump control.
4. Measure charge on individual jar tests to derive a numerical charge value for the “best jar.”