# OPERATIONS MANUAL

# LCA5


## Laboratory Charge Analyzer

Revised Oct 1, 2021

CHEMTRAC

# Contents

# 1. Product Description

## 1.1 General

The Laboratory Charge Analyzer (LCA) is primarily used in water treatment applications to determine how much coagulant or polymer is required to neutralize the charge of an aqueous sample, such as raw water coming into a water treatment plant. A "charge neutralizing dosage" of coagulant is very often an optimum (or near optimum) coagulant dosage necessary to achieving good TOC reduction and reliable filter performance. Chemtrac's LCA5 allows the user to determine the charge neutralizing dosage of coagulant in under 5 minutes in most cases, which has significant advantages compared to the time needed to perform conventional jar testing. The LCA is not intended to be a replacement for jar testing, but rather a supplemental tool to help streamline and optimize the process of determining an optimum coagulant dosage.

The LCA provides a real-time measurement of charge neutralization using streaming current technology. Streaming current is a term which is commonly interchanged with "charge" or "charge measurement." Streaming current is a very small current that is generated by the mechanical separation, or shearing, of ions from the diffuse layer that surrounds charged species like macromolecules and colloidal particles (Figure 1).

A streaming current device (Figure 2) is easily identified by its reciprocating plastic piston that travels inside the annulus of a plastic probe fitted with two electrodes. The movement of the piston displaces the liquid in the annulus, forcing the liquid to travel rapidly across the piston surfaces. Soluble and colloidal charged species in the sample attached to the reciprocating piston via Van Der Waals attraction forces, and the rapid fluid motion across the piston surface, causes loosely bound counter-ions to be sheared away from the charged species attached to the cylinder walls. Electrodes in the cylinder measure this tiny current generated by the sheared counter-ions. The signal is electronically processed, and the resulting readout is called the streaming current value (SCV), which can be thought of as a mV value, but actual correlation to a true mV value is not possible unless the instrument is calibrated using zeta potential measurement.

The SCV is sometimes referred to as "Particle Charge" or "Ionic Charge" measurement by other manufacturers.

The LCA allows the user to perform a manual or automatic titration with either an inorganic coagulant like Alum or low molecular weight organic polymer. The LCA is unique among lab charge analyzers in that it can also adjust or control the pH before or during the charge titration, and this allows the LCA to more accurately determine the optimum coagulant dosage (versus those units which cannot control pH). Sample pH is especially important when working with inorganic coagulants and pH must be taken into consideration when measuring charge in order to obtain accurate results.

Higher alkalinity samples with pH >7 may require the pH to first be lowered with additions of acetic acid to ensure the aluminum hydroxide is available as a cationic species (e.g. $Al(OH)^{2+}$) which is necessary to obtain a measurable charge neutralization. This is akin to free chlorine measurements where the sample pH is sometimes required to be buffered (or pH compensated) in order to improve measurement accuracy. Lower alkalinity samples will possibly require the addition of a base (e.g. sodium hydroxide) in order to maintain minimum pH level for accurate results. This manual will cover many of the most important aspects of the laboratory charge analysis testing procedures, but it is still highly recommended to consult with Chemtrac's application specialist to ensure the test procedure is optimized for the user's unique application.

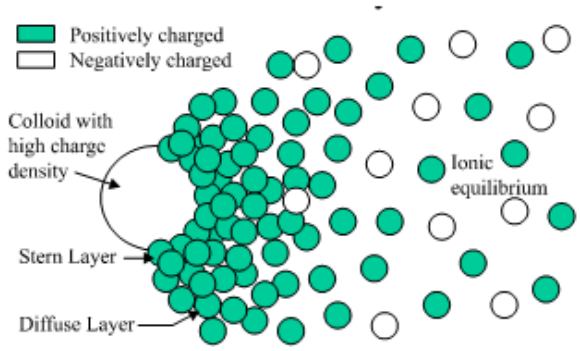


**Figure 1 - Double Layer Charge**

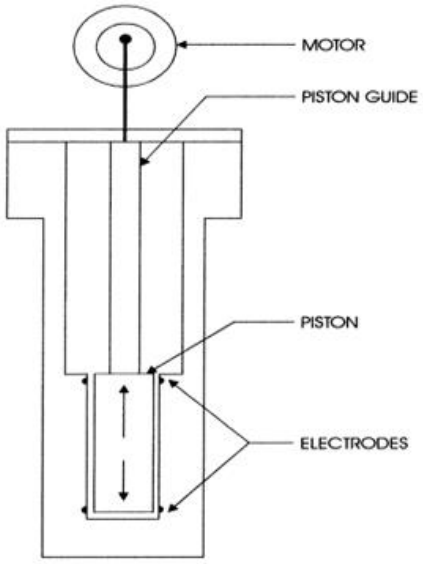


Figure 2 - Streaming Current Sensor

## 1.2 Applications

### 1.2.1 Determining Coagulant Dosage

In water treatment applications, the LCA provides a fast and simple method of determining the coagulant or polymer dosage needed to obtain charge neutralization which generally results in excellent reduction of turbidity (NTU) and organics (NOM/TOC), while also allowing for more efficient filter performance. The test procedure involves titrating a raw water sample with the primary coagulant until a neutral charge is obtained. This allows the user to determine the dosage of inorganic coagulant to reach neutral. As covered in this manual, the test procedure may require the user to adjust the sample pH to optimize response to the inorganic coagulant, and the user may also need to first introduce other process treatment chemicals (e.g. chlorine, flocculant) to the sample before titrating with the primary coagulant.

It is highly recommended to verify the LCA results using jar testing until confidence in the LCA is established across the full spectrum of water quality changes the WTP experiences. Comparison to jar testing should be done on a routine basis to verify the LCA is still providing optimum results, and to also keep operations practiced at performing jar testing.

**Important Note:** A coagulant dosage that achieves charge neutralization is generally (not always) required in order to obtain optimum water treatment results, especially as it concerns Total Organic Carbon (TOC) reduction and achieving optimum unit filter run volume (UFRV). However, there are several factors which go into determining a WTP's coagulant dosage, and these sometimes require a lower or higher dosage then what is needed for charge neutralization. For example, under certain conditions, such as elevated TDS levels in raw water where certain anions like sulfate may be more prevelant, the dosage required to achieve acceptable "sweep floc" performance for NTU reduction can be significantly lower than the dosage required to achieve charge neutralization. See section 3.1 of this manual for more information on the various factors that can cause discrepancies between the LCA result and what is an actual optimum dosage.

### 1.2.2 Determining Base (e.g. Lime) Dosage

When the automatic pH titration option is utilized, the LCA can also be used to determine how much base (e.g. caustic, lime, potash) is needed along with coagulant to achieve charge neutralization at a given target pH (note: pH must be within a range that allows charge measurement to respond adequately to the coagulant). This allows the user to quickly determine the minimum dosage required for both the base and the coagulant.

**Important Note:** The minimum amount of coagulant and base required to reach neutral generally provides very good treatment outcomes but does not always produce the absolute lowest sedimentation turbidity results. A lower settled turbidity is sometimes obtainable by feeding a higher coagulant dosage (along with a higher base dosage) then what the LCA call calls for. However, when settled turbidity becomes a main determining factor for coagulant dosing, a WTP may end up feeding as much as 30% more in chemicals then what is otherwise needed to maintain optimum filter performance and finished water quality. In some cases filter run times can even suffer when chemical dosages are raised in order to achieve lower settled turbidity. The reason for this is because turbidity (a measurement of clarity) does not reliably correlate with total suspended solids (TSS), and most importantly it provides no information on floc size. It is important to weigh out all the relevant "optimization" factors (e.g. UFRV, effluent NTU &

particle counts, TOC reduction, etc) when determining coagulant dosage.

#### 1.2.3 Determining Polymer Dosage

In wastewater applications, the LCA can potentially be used to help optimize polymer dosage for clarification and dewatering. Measurements of centrifuge centrate, or gravity belt thickener or belt filter press filtrate, can be made to see where charge is running, and confirm proper dosing. The sample can also be titrated with a cationic or anionic polymer to determine gauge how far the sample is from neutral. This manual does not offer details on this application. Please contact Chemtrac for more information.

#### 1.2.4 Wet End Charge Demand

In Pulp & Paper applications, the LCA is used to determine the cationic or anionic charge demand of a sample which helps quantify swings in charge that can occur on the paper machine. Charge demand is determined by titrating a sample with a polymer of opposite charge (typically DADMAC or PVSK). This manual does not offer details on this application. Please contact Chemtrac for more information.

#### 1.2.5 Determination of Isoelectric Point

The LCA can be used to find the Isoelectric Point (IEP) of dispersions using an Acid or Base titration. The IEP is the pH at which a molecule or particle carries no net electrical charge. If the sample is cationic, the sample is titrated with a base until the SCV value reaches 0 (or neutral). If the sample is anionic, an acid is used instead. This manual does not offer details on this application. Please contact Chemtrac for more information.

#### 1.2.6 Other Applications

The LCA can be used in a variety of other applications where soluble/colloidal charge is of concern.

## 1.3 Model Designation

The LCA is available in 8 different model configurations. The model number is located on serial number sticker and appears on the display under Status.

| MODEL | PUMP 1 (COAGULANT) | PUMP 2 (BUFFER) | pH w/ TEMP |
|---|---|---|---|
| LCA5.2000 | | | |
| LCA5.2001 | | | ✓ |
| LCA5.2100 | ✓ | | |
| LCA5.2101 | ✓ | | ✓ |
| LCA5.2201 | ✓ | ✓ | ✓ |
| LCA5.2110 | ✓* | | |
| LCA5.2111 | ✓* | | ✓ |
| LCA5.2211 | ✓* | ✓ | ✓ |

* Syringe Pump Upgrade

## 1.4 Included Items

Each LCA model includes:

- Power adaptor
- Probe and piston
- Cleaning brush
- Manual

Note: A sample beaker is not included. User will need to provide a 1 to 2 liter beaker.

Models with automatic titration pump(s) will include:

- 120 ml titrant bottle (1 per pump)
- 5 cc graduated cylinder
- Priming syringe
- Spare Pump Tubing Kit

Models with pH probe will include:

- pH Probe Fill Solution
- pH storage bottle
- pH cleaning bottle

## 1.5 Options

#### 1.5.1 pH with Temperature

The pH and temperature probe option allows the user to easily perform pH adjustment prior to or

during the coagulant titration. A pH measurement is necessary for understanding and predicting the LCA's response to a given coagulant. If pH is not in a suitable range when performing titrations, the results will not be accurate.

### 1.5.2 Automatic Titration Pump

The standard titration pumps used by the LCA are solenoid pumps capable of dispensing approximately 50 µL per stroke. These pumps are used with dilute solutions of chemical, typically in the 0.5 to 2% range. Pump 1 is used to titrate coagulant. Pump 2 is used to titrate an acid or base and requires the pH with Temperature option.

### 1.5.3 Syringe Pump

Certain types of coagulants are recommended by the manufacturer to be fed neat (undiluted) when performing LCA or jar testing because these coagulants can degrade in performance (as well as charge) when diluted. For those situations, the LCA is available with a Syringe Pump upgrade option that is capable of injecting neat coagulant in 0.5 µL increments.

### 1.5.4 Roll Away Case

The roll away case allows for easier transport and safe storage of the LCA.

## 1.6 Specifications

| | |
|---|---|
| Dimensions | Width: 8.5”<br>Depth: 9.5”<br>Height (Stand Lowered): 15”<br>Height (Stand Raised): 23” |
| Weight | 16 lbs. (7.3 kg), 19 lbs. (8.6 kg) with syringe pump |
| Power Requirements | 24 VDC, 1.5 A. (Supplied with Universal Power Adapter) |
| Environmental Temperature | 34-120°F / 0-50°C |
| Enclosure | Powder Coated Aluminum |
| Display | 7” capacitive touchscreen, WVGA 800 x 480 |
| Measurements | -SCV (Streaming Current Value, or mV)<br>-Coagulant Dose: parts per million (ppm) (Optional)<br>-Charge Demand: µeq/l (Optional)<br>-Automatic pH Titration (Optional)<br>-pH & Temp (F/C)* (Optional)<br>-Acid/Base Dose: parts per million (ppm)* (Optional) |
| Sample Size | 1000 mL to 2000 mL (Beakers not included) |
| Materials in contact with sample | Delrin, 316 stainless steel |
| Titrant Pumps (Optional) | Solenoid operated micro-pump with 50 µl dispense Volume, or optional Syringe Pump with 0.5 ul (per step) dispense volume. Material of construction: POM, PTFE, FKM. |
| Titrant Bottles (Optional) | 120 mL Polypropylene Bottles |
| pH Probe (Optional, Standard on LCA-3) | Measurement range 0 – 14. |
| Temp Probe (Optional, Standard on LCA-3) | Measurement range 0 – 140 F |

## 1.7 LCA Components


Figure 3 – LCA Components

1. Height Adjustment Handle
2. 7” Touchscreen Display
3. Probe & piston
4. Sample Stirrer
5. pH and Temperature Probes (Optional)
6. Titrant Container for Coagulant (Optional)
7. Titrant Container for Acid or Base (Optional)
8. Coagulant Pump (Optional)
9. Acid or base Pump (Optional)
10. Probe release tab.

### 1.7.1 LCD Display & Menu Keypad

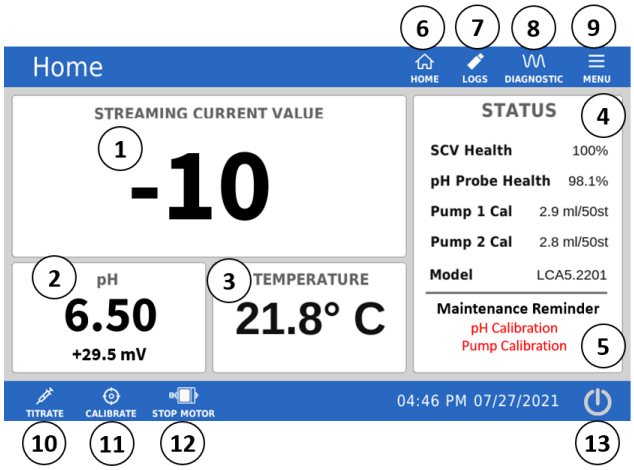


Figure 4 – Display (Home Screen)

1. Streaming Current Value (SCV). Range -1000 to +1000

2. pH reading (Optional). Range 0 to 14

3. Temperature reading (Optional). Provides compensation for pH readings when ATC is enabled.

4. SCV Health. Indication of SCV signal quality. A value <95% (prior to titration) could indicate maintenance is required or sample is too high in solids.

   pH Probe Health (Optional). >96.5% is required for accurate and responsive pH readings. <96.5% indicates pH probe requires cleaning or replacement.

   Pump 1 Cal / Pump 2 Cal (Optional). Only appears on units with titrant pump option. Shows the calibration value of the titrant pumps. Should be >2.4 ml/50st.

   Model. Shows the LCA model number (see section 1.3 for model breakdown).

5. Maintenance Reminder. Indicates when routine calibration and cleaning is required for sensors and pumps.

6. Home. Returns the user to the Home Screen.

7. Logs. Accesses the data log where past titrations can be viewed.

8. Diagnostics. Displays the SCV waveform view, which is used to help diagnose cause for low SCV Health.

9. Menu. Used to access all LCA user settings as well as support videos.

10. Titrate. Starts the titration.

11. Calibrate. Access to pH and Pump Calibration menu.

12. Start / Stop Motor. Allows user to start and stop LCA motor (Note: Motor will start automatically when Titration starts).

13. Standby Button. Dims the display and shuts off motor and light.

### 1.7.2 Stand Release (Raise & Lowers Stand)


The Stand Release button on top of the enclosure is used to raise and lower the LCA. Raise the LCA to place a sample beaker under the sensor and then lower to submerge the sensor into the sample.

### 1.7.3 Probe and Piston

The probe and piston are both made of durable Delrin plastic and are designed for quick and easy removal. Press the silver tab directly above the probe to remove. The piston is removed by turning counterclockwise. These are critical components of the LCA which produce the streaming current reading. Routine cleaning of these parts is important to maintaining accurate charge measurement results. Refer to maintenance instructions in this manual for cleaning procedure.

### 1.7.4 Beaker (Optional)

Beakers are not supplied with the LCA. Recommended beaker size (volume) is 1,000 mL to 2,000 mL. Round or square beakers, glass or plastic, are fine to use.

### 1.7.5 Integrated Stirrer

The LCA is equipped with an integrated stirrer which spins at approximately 550 RPM and has a safety clutch design feature that prevents the stirrer from rotating if it comes into contact with the sample beaker or the users fingers.

***Note: When removing the LCA probe, rotate the stirrer by hand so the blade is not under the probe.***

### 1.7.6 Coagulant / Polymer Titrant Container (Optional)

Certain LCA models come equipped with a 120 mL plastic bottle used to hold a dilute solution of coagulant (e.g. Alum, Ferric) or polymer (e.g. Dadmac). This titrant container is located on the left side. The coagulant needs to typically be diluted down into a 1% to 2% solution. If the LCA is equipped with the optional syringe pump, the container for holding the coagulant will be glass and hold 10 mL of neat coagulant.

### 1.7.7 Buffer Titrant Container (LCA-3 Only)

Certain LCA models come equipped with a 120 mL plastic bottle used to hold a dilute solution of acid or base. This titrant container is located on the right side. A base like sodium hydroxide can be used when pH needs to be raised during the titration to maintain optimum pH. The raising of the pH during the charge titration is most often required on lower alkalinity / lower pH waters, especially when feeding acidic coagulants (e.g. alum or ferric). It is generally recommended to dilute the base (e.g. caustic or lime) to a 0.5% concentration. A 1% concentration can be used when dosing requirements are higher.

Acetic acid is sometimes required to reduce the sample's pH to ensure optimum response to the coagulant (see Section 3.1.10 and 3.1.11 for more info). Unlike other acids (e.g. sulfuric acid), acetic acid has little to no impact on the coagulant titration results and is therefore the only recommended acid to be used for lowering the sample pH. Acetic acid concentration should be diluted to 2 to 5%. Other acids, like Sulfuric Acid, should only be used to lower the pH of LCA's sample if that acid is used in the treatment process for pH reduction. Titrant pumps with suitable wetted materials can be ordered if there is a requirement to feed an acid other than acetic acid.

### 1.7.8 Coagulant / Polymer Titrant Pump (Optional)

The coagulant titrant pump is located to the left of the probe. Each stroke of the pump delivers approximately 50 µl of coagulant. **This pump cannot be used to titrate neat (undiluted) coagulants.** An optional Syringe Pump, capable of dosing down to 0.5 µL increments, is available for customers who need to feed their coagulant neat.

### 1.7.9 Buffer Titrant Pump (Optional)

The buffer titrant pump is located to the right of the probe. Each stroke of the pump delivers approximately 50 µl of buffer solution. This pump cannot be used to titrate neat (undiluted) buffers.

### 1.7.10 pH electrode and Temp probe (Optional)

The pH electrode and temperature probe are located to the right side of the LCA's probe. The pH probe is connected to a BNC male connector for easy removal. It is important to keep the storage solution bottle attached to the pH probe when not in use. The recommended storage solution is a 3 to 5 M KCl electrode storage solution. The temperature probe is permanently affixed to the LCA.

# 2. User Menu

The user menu is accessed by pressing the Menu icon in the top right corner of the display. The menu is categorized into 5 categories: Titration, Calibration, General, Advanced, and Support.

## 2.1 Titration

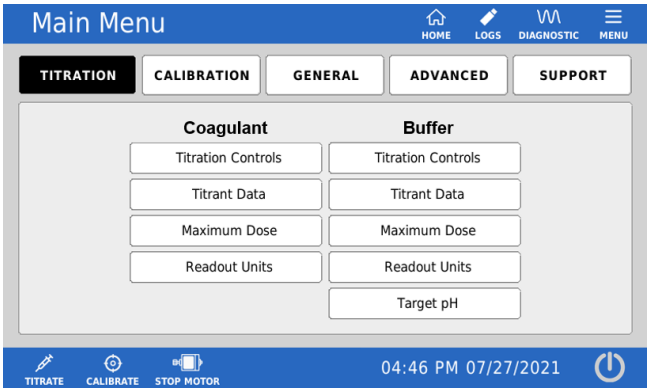


Figure 5 – Titration Menu

The Titration menu will only appear on models which have automatic titration pumps. The Coagulant settings will appear for any model which has a single pump, and the Buffer settings will appear for models with two pumps. Under the Titration menu the user can modify settings to control the rate at which chemical is titrated into the sample, specify the chemical concentration, select the units (e.g. ppm) used when reporting the dosage results, specify a target pH, and set a maximum dose value.

### 2.1.1 Titration Controls - Coagulant

The first screen of the Coagulant Titration Controls menu allows the user to select between the following modes:

- Adaptive Fast – This is the recommended mode to use for most charge titrations. The adaptive titration modes automatically speed up and slow down the rate of titration based on the rate of change in the charge reading. Adaptive Fast mode will complete the charge titration generally in 3 to 6 minutes. **Note:** If charge titration finishes in under 2 minutes, there will likely be overshooting of the neutral endpoint. If slowing down Adaptative Fast titration controls does not prevent overshooting, then Adaptive Slow mode may need to be used.
- Adaptive Slow – This is the recommended mode to use for charge titrations when Adaptive Fast proves to titrate too quickly and overshoots the

neutral endpoint by more than 10 SCV units. This mode is typically required in applications where coagulant dosage is low (e.g., <10 mg/l).
- Disabled – Turns off the charge titration feature and allows the LCA to just perform a pH titration.

After selecting the preferred mode, press the Next button to access the titration control settings for that mode.

These settings control the "Dosing rate", which is defined as the amount of chemical titrated in a 1-minute time interval, and allow the user to tune the titration speed so it is completed in a timely manner. A good time for completion is generally defined as 3 to 5 minutes if only coagulant is fed, and 3 to 7 minutes if a buffer is fed along with the coagulant. If the titrations are taking <3 minutes or >7 minutes, then the below dosing rates will require adjustment.

**Coagulant Titration Controls**

**Start** - Set for 50% of the typical coagulant dosage needed to treat the sample. Lower this value if titration is finishing in under 3 minutes.

**Minimum** – Typically set for 1 ppm (when in ppm readout mode), but can be raised titration appears to be consistently to slow near the end (when reading approaches zero). Note: Raising this setting too high will result in overshooting the endpoint.

**Maximum** - Set for 50% of maximum coagulant dosage needed to treat the sample (e.g. dosage required during rain events). Lower this value if the titration is finishing in under 3 minutes.

For example, if working with a raw water sample that typically requires a coagulant dosage of 10 ppm and sometimes the dosage needs to be as high as 50 ppm during rain events, then the following settings would be recommended.

Start = 5 ppm (50% of typical 10 ppm dose)

Minimum = 1 ppm

Maximum = 25 ppm (50% of max 50 ppm dose)

Using these settings, the LCA will automatically adjust the dosing rate based on changes it measures in the charge reading. If the titration were to finish in under 3 minutes, the Start and Maximum setting will need to be lowered.

### 2.1.2 Titration Controls - Buffer

The pH Titration Control menu allows the user to enable or disable the pH titration feature, and provides settings for adjusting the dosing rate of the buffer.

When titrating with an acid, the buffer titration controls (and acid concentration) should be adjusted so that the Target pH is reached within 1 to 3 minutes.

When titrating with a base, adjust the buffer titration controls for a slower rate of addition. The objective is not to try and keep the pH at the target value during the whole titration. Instead, it is optimum for the pH to be allowed to drop below the target during the first 75% of the titration. The main objective when tuning these controls is not to allow the pH to drop more than 0.5 units of the target pH, and to gradually bring the pH closer to the target pH (without overshooting) as the Streaming Current Value (SCV) approaches neutral.

**IMPORTANT** - The SCV can respond faster than pH to the addition of base, and so adding too much base too quickly, or especially adding more than needed, will cause the Streaming Current Value (SCV) to go more negative which then causes the LCA to feed more coagulant in response. This can result in an overdose of both coagulant and base. This situation is more likely to occur as the pH probe ages and becomes more sluggish in its response.

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**Buffer Titration Controls**

**Proportional Gain** - Used to speed up or slow down the dosing rate. Raising the Proportional Gain will increase the rate at which the buffer is dosed into the sample. Lowering this setting slows down the dosing rate. When doing titrations with a base (e.g. caustic), start with 0.3 or 0.4 and only raise to a higher value (e.g. 0.5 to 0.6) if the pH is seen to consistently drop by more than 0.5 pH units away from Target pH during the charge titration and/or if the titration is seen to consistently take >6 minutes to complete. A good

proportional gain setting will have the following outcomes:

- pH drops no further than0.5 units of target pH during the titration.
- No overshoot of the target pH, especially during the first 75% of the titration.
- Titrations complete in under 7 minutes.

When doing titrations with an Acid, the Proportional Gain setting should be adjusted for whatever value produces a timely pH adjustment (1 to 2 minutes) with minimum overshoot (<0.05 pH units).

**Minimum** – Typically set for 0.5 to 1.0 ppm. This setting can be raised if pH adjustment is too slow at the end of the titration.

**Maximum** – Typically set for 25 to 50% of typical buffer dosage. This setting limits how much acid or base can be added in a 1 minute interval.

**Tip** –It is better to start with lower values and have the pH adjustment be on the slower side as this ensures more accurate coagulant dosage determination.

Note: As the pH probe ages, its response may become more sluggish and that would possibly require lowering these settings to slow down the buffer addition and give the pH probe more time to respond. A pH probe with <96% health is more likely to be sluggish and less accurate. If advanced cleaning does not raise health to >96%, consider replacing the pH probe to ensure the most accurate titration results.

### 2.1.3 Titrant Data

This menu allows the user to enter the solution strength (%) of the titrant (i.e. coagulant or buffer) and to select whether the buffer is an acid or base.

**IMPORTANT** – When preparing titrant solutions (also referred to as stock solutions), it is necessary to use the same method to prepare the solution as is being used at the full-scale level (e.g. plant SCADA) to calculate the chemical dose. There are generally 3 methods used: volumetric, liquid weight, and dry Weight. If the titrant solution(s) are not prepared using the same method, the LCA's dosage results will not be accurate.

**IMPORTANT** - For LCA models which do not have the syringe pump option, a dilute coagulant solution must be used. Widely used commodity coagulants like aluminum sulphate, ferric chloride and aluminum chlorohydrate (ACH) can be diluted. However, this is not true of every other type of inorganic coagulant. Certain types of pre-hydrolyzed coagulants like polyaluminum chloride (PACl), for example, are very unstable once made into stock solutions and therefor recommended to only be used neat. Check with your supplier to ensure your coagulant can be diluted and to see how long the stock solution can be expected to last.

When making a stock solution, one will need to consider what is the optimum solution strength. That will depend on the expected range of dosing that will be required and the sample size.

If the titrant solution is too high in concentration, it can result in the following issues:

- Target endpoint is significantly overshot
- Lower resolution in dosage results
- Less precision in dosage results

If the titrant solution is diluted too much, it will take an excessively long time to complete the titration. When optimum titrant solution strength is used along with optimum titrator settings, the titrations will generally finish in 3 to 6 minutes.

The solution should be dilute enough so that a minimum of 1 mL (approximately 20 pump strokes) is required to complete the titration. If A strength of 0.5 to 2% is typically what is used with most inorganic coagulants, except when calculating dosage as aluminum (Al) or as aluminum oxide ($Al_2O_3$), in which case the solution strength will be lower. If unsure what solution strength to use, contact LCA technical support at chemtrac@chemtrac.com or 770-449-6233.

When using optional Syringe Pump, the solution strength is set to equal 100% if calculating the dosage as liquid product, or it is set to equal concentration of active product for reporting dosage as that active product (e.g. 48% for Alum when calculating dosage as dry aluminum sulfate). When using the syringe pump, the user also has the option of entering the specific gravity of the sample which allows for ppm result to be expressed as parts per million weight/volume

(ppm w/v), which is equivalent to mg/l. There is also a setting for viscosity range. Select the viscosity range that is applicable to the coagulant (or polymer) that is being used. Most inorganic coagulants can be set for the “Low Viscosity 1-40 cps” range, while organic polymers will require a higher viscosity setting like “Medium Viscosity 20-80 cps”.

Note: If air bubbles keep appearing in the glass syringe, a higher viscosity setting may be required. A higher viscosity setting will cause the syringe pump to run slower which can be necessary to prevent air bubble formation with higher viscosity samples. Some coagulants can see their viscosity increase with time and should therefore be replaced on a schedule necessary to prevent problems with syringe pump operation.

#### 2.1.4 Maximum Dose

If the LCA is performing a titration and reaches this “Maximum Dose,” it will stop the titration and display an error message. This prevents the pump from running continuously in the event the titrant bottle runs empty.

Set Maximum Dose for a value that is 1.5 to 2x greater than the highest expected maximum dosage required to treat a sample.

#### 2.1.5 Readout Units

The dosage readout on the LCA can be set for:

- ml (milliliter)
- ppm (parts per million)
- µeq/l (micro equivalents per liter)

#### 2.1.6 Target pH

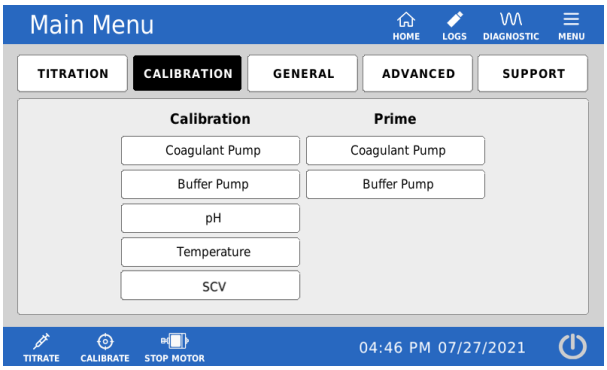
Set the target pH to the value needed to achieve accurate dosage determinations for the coagulant being utilized. If unsure what to use, refer to sections 3.1.10 to 3.1.13.

The Deadband setting determines how close pH needs to be to the target pH before the titration is allowed to finish. Set the Deadband for 0.05 to 0.10.

The Stabilization Time setting is how long the LCA waits to ensure the pH stays within the Deadband range before proceeding. This setting is typically recommended to be set at 15 to 30 seconds. Note: Colder water with low ionic strength (low TDS) may require a longer stabilization time.

**Note: pH is very important to the charge measurement accuracy and to achieving accurate coagulant dosage determination. If an inorganic coagulant is introduced into a sample that is not in a pH range that allows soluble cationic species to form, then the dosage determination will not be accurate. See section 3.1.10 to 3.1.13 for more information on the importance of pH when conducting testing on the LCA.**

## 2.2 Calibration




The calibration menu is accessed by pressing the **MENU** button and then pressing **CALIBRATION.** From this menu the user can prime and calibrate the Titrant Pump(s), calibrate the pH and temperature probes, and adjust the Streaming Current Value (SCV).

#### 2.2.1 Titrant Pump Priming & Calibration (Optional)

These instructions are only applicable LCA5 models with a standard titrant pump(s). See Section 2.2.5 for instructions related to the Syringe Pump.

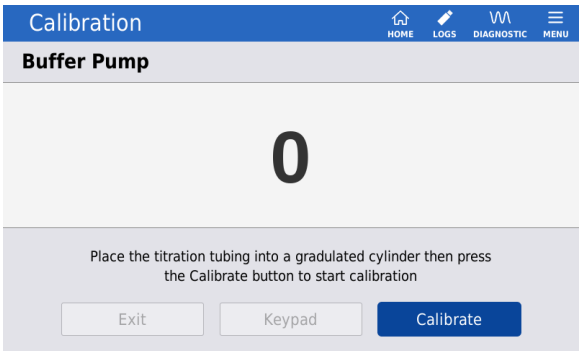
The priming and calibration of the titrant pump(s) can be performed from this Calibration menu, or by pressing the “Calibrate” icon located in the bottom left corner of display.

##### 2.2.1.1 Pump Priming

To prime the titrant pumps, first ensure the titrant bottles are at least half full and the titrant tubing is fully submerged. Next place a small beaker under the titrant tubing which is attached to the temperature probe, and then press the **Coagulant Pump** and/or **Buffer Pump** buttons located under **Prime**. The button will change color and the pump(s) will begin to stroke once per second. Both pumps can be primed at the same time. Once liquid is being dispensed and no air bubbles are left in the titrant tubing, stop the priming by pressing the Pump button(s). A short instructional video on priming can be watched by going to the Support page. The video also covers how to use the priming syringe if a pump fails to prime.

#### 2.2.1.2 Pump Calibration

To calibrate the titrant pumps, press the **Coagulant Pump** or **Buffer Pump** button located under **Calibration**. The below screen will appear.




The instructions on the display will alert the user to make sure the bottle is full of coagulant before proceeding. It is not required that the bottle be completely full, but it is recommended to be at least 50% full. Ensure the pump tubing is fully inserted into the bottle.

Place the empty 5 mL graduated cylinder (provided with LCA) under the outlet tubing and press Enter to continue. Ensure the chemical is being injected into the cylinder. Closely inspect the pump tubing to ensure no air bubbles are present as this would indicate a possible leak which can cause inconsistent titration results (see section 4.5 for troubleshooting tips if bubbles are present). The pump will stroke 50 times and then stop.

Once the pump stops, inspect the graduated cylinder to see how much chemical was dispensed. The dispensed volume is typically in the range of 2.3 to 2.8 ml. Press the Keypad button and then enter the dispensed volume. Press **Save** to finish the calibration. It is recommended to, on occasion, repeat this calibration a second and possibly third time to verify repeatability to within 0.1 ml.

### 2.2.2 pH Probe Calibration (Optional)

These instructions are only applicable if the LCA is equipped with the optional pH probe. It is recommended to calibrate the pH probe at least once per week. A one-, two-, or three-point pH calibration can be performed; but a two-point calibration using 4 and 7 buffers is the recommended method. Two small 150 mL beakers are provided for holding the 4 and 7 buffers. A wash bottle with DI water will be needed for rinsing the probes.

Begin the pH calibration by pressing the **pH** button under **Calibrate**. Follow the on screen prompts to perform the calibration. The pH slope and offset results are displayed after the calibration is completed. A slope higher than 57.5 mV is very likely to be sufficiently responsive and accurate, whereas a pH probe with a slope less than 56.5 mV is more likely to be sluggish and less accurate. Routine and advanced cleaning will help maintain a slope >57 mV. Routine cleaning is performed after each titration. Begin by rinsing the pH probe (ideally with DI water if available) and then soak in Cleaning Solution (a 0.1 to 0.3 M HCl) for a short time (30 sec to 5 min). Then do a final rinse and place the storage solution bottle onto the pH probe. Advanced pH probe Cleaning is covered in section 4.5.

### 2.2.3 Temperature Calibration

The temperature probe comes from the factory calibrated. If temperature does not appear accurate, calibration can performed by comparison to a calibrated temperature probe. This reference calibration is typically done at two points. The first point is a stable, room temperature sample of water. The second point is at 0°C using an ice bath.

It is important to use as pure of water as possible (distilled or RO Purified) for the ice bath. To make a calibration ice bath:

- Use pure water to make ice and then crush the ice to pieces smaller than 1 cm using a blender. Add some pure water along with the ice to make it easier to blend and then drain the water.
- Fill the container to the top with the crushed ice (an insulated container is best).
- Fill the container to within 1.5 cm of the top with pure water.

Remove the LCA probe, piston, and pH probe so they don't interfere with the container during this procedure. Next, carefully lower the temperature probe in the middle of the container (horizontally and vertically). This is your 0°C reference point. The stirrer will also need to go into the ice bath because of its close proximity to the temperature probe, but do not turn the stirrer on while in the ice bath.

Using the calibrated reference temperature probe along with an ice bath and room temperature sample, you can perform a 2 point calibration on the LCA's temperature probe. Simply go to Menu, then to Calibration, and finally select Temperature. Follow the onscreen prompts.

### 2.2.4 SCV Gain Adjustment

Calibration of the SCV is generally not required unless the customer is wanting to try and match the LCA reading to their online SCM reading on the same sample of raw water. This can be helpful to do when using the LCA to verify the online SCM (see videos under Support for more info on how to use the LCA to verify the online SCM). A typical method of calibrating the SCV is to submerge the sensor in raw water (with no coagulant) and adjust the SCV value for a reading of -200. But unless the goal is match the LCA reading to an online SCM reading, it is not necessary to do this adjustment because the actual reading of the raw water does not impact the LCA's titration result. The SCV calibration can be adjusted to give a reading of -100 or -400, and the titration results would be the same either way. This is because adjusting the gain to obtain a specific value on raw water does not alter the "zero point". And the Zero Point will be accurate as long as the probe and piston are healthy and clean. If the zero point was suspected to be in error, a new probe and piston should be tested to see how the titration results compare. Polymer Solutions of POLYDADMAC and PVSK can also be purchased for verifying the LCA zero point (see procedure under section 4.7.2)

### 2.2.5 Syringe Pump Priming & Verification Procedure (Optional)

These instructions are only applicable to the LCA5 models with optional 100 µl syringe pump.

1. There must be no air bubbles in the syringe when performing titrations as this will produce inaccurate results. An air bubble resting near the tip of the syringe plunger (like shown in below picture) can be difficult to dislodge using the "Flush" and "Prime" features on the LCA, especially when doing this with coagulant. For this reason, it is recommended to first "Flush" the system using DI water.

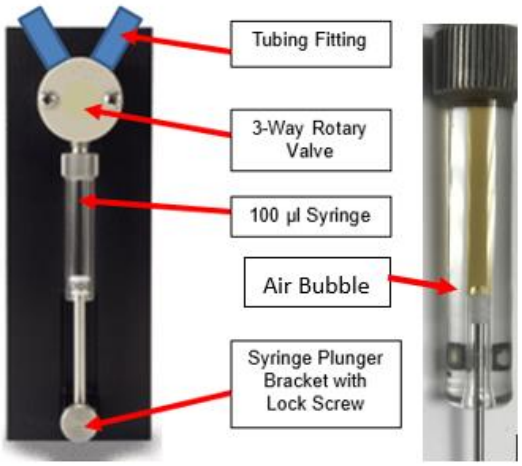



**Figure 6 – Syringe Pump Components**

2. Fill a small container with DI water. Remove the syringe pump's inlet tubing from the titrant container and insert the tubing into the container with DI water.
3. Place the 5 mL graduated cylinder directly under the syringe pump injector and gently lower the stand so that the injector is positioned right above the cylinder.
4. Press the "Prime" button on the LCA. The syringe pump will begin to cycle.
5. Closely inspect the syringe to see if any air bubbles are still present, especially near the

tip of the plunger. If repeated cycles (e.g. 20 cycles) do not dislodge the air bubble, then perform steps 6 to 8. Otherwise, if there are no air bubbles present, skip to step 9.

6. Loosen the Lock Screw on the Syringe Plunger Bracket and then slide the plunger forward so it is removed from the bracket. Then unscrew the syringe from the 3-way rotary valve by spinning counterclockwise.
7. Once removed, submerge the lower half of the syringe (the side with the threaded connector) in DI water and rapidly move the plunger back and forth 5 to 10 times, only pulling the plunger back about halfway before pushing forward. This rapid back and forth action will dislodge and remove the air bubble. With the syringe full of water and free of bubbles, push the plunger forward just far enough to allow the syringe to be screwed back onto the 3-way rotary valve, making sure it is only screwed on finger tight. Then pull the plunger backwards and fully reinsert the head of the plunger into the Syringe Plunger Bracket, making sure the thumb screw is loosened enough to allow the head of the plunger to enter the bracket and go in as far as it can go. Once it is verified to be inserted all the way, fully tighten the thumb screw.
8. At this point there will be air in the syringe, but there should be no air bubbles within 1/4" (6 mm) of the tip of the plunger. Repeat steps 2 to 4 to flush out the remaining air in the syringe and tubing and **be sure to not cycle power or press the Menu button prior to completing the rest of this procedure.** (Note: cycling power or pressing Menu button will result in the syringe pump needing to re-initialize which would cause the DI water in the syringe pump to be dispensed into the coagulant titrant container when performing step 11).
9. The syringe should now be full of DI water and no air bubbles present. Remove the tubing from the container with DI water and dry off the outside of the tubing.
10. Fill the titrant container full of coagulant, screw on the titrant bottle cap, and then insert the tubing through the hole in the titrant container cap making sure the tubing goes to the bottom of the container.
11. Place the 5 mL graduated cylinder directly under the syringe pump injector and, if necessary, gently lower the stand so that the injector is right above the cylinder.
12. Press the "Coagulant" button under Prime on the LCA. The syringe pump will begin to cycle.
13. After around 10 cycles, closely inspect the syringe to see if any air bubbles are present in the syringe, especially near the tip of the plunger. If there is an air bubble near the tip of the plunger, allow the pump to keep cycling another 10 times. If bubble is still present, stop the priming and repeat this procedure starting with step 2. Otherwise, proceed to step 14 if there are not bubbles in the syringe.
14. Completely empty the 5 mL graduated cylinder and place back under the injector fitting. Repeat step 11 and verify approximately 1.3 to 1.6 mL of coagulant is dispensed. If outside this range, review section 4.5 for instructions on syringe pump maintenance and troubleshooting or contact Chemtrac at 770-449-6233 for troubleshooting assistance.
15. When prompted to "Enter volume pumped in mL" at the end of the priming sequence, leave the pump value set for 1.5 ml. Note: As long as the result is within 1.3 to 1.6 ml, the setting is left at 1.5 mL for the following reasons:
    a. If there is no air in the syringe or leaks in the system, the syringe pump is very accurate and reliable in terms of dispensing volume.
    b. The graduated cylinder has an accuracy of +/- 0.1 ml.
    c. A small amount of coagulant can sometimes remain adhered to the injector tip and result in the volume shown in graduated cylinder to be low by 0.1 ml.
16. Rinse off the neat coagulant from the injector tip by placing in a beaker with water and gently swirling the water around for 10 seconds. Warning: If neat coagulant is left on outside of injection it will impact the next titration performed and/or crystalize and plug up the injector tip.
17. This completes the Syringe Pump Priming and Verification procedure.

# 3. Operation

## 3.1 Water Treatment – Determining Optimum Coagulant Dosage

### 3.1.1 Introduction

The LCA allows the user to quickly determine the dosage of coagulant necessary to reach charge neutralization. This result will often correlate to the optimum full-scale process coagulant dosage needed to obtain optimum treatment results, especially when it concerns achieving best obtainable total organic carbon (TOC) reduction and filter performance (e.g. unit filter run volume, effluent NTU). The test usually takes no longer than 5 to 7 minutes to perform. While the testing procedure for many WTPs will be very simple and only involve the addition of one or possibly two chemicals (e.g. coagulant and flocculant), there are a wide variety of scenarios in which the LCA is utilized and as a result some situations require a more comprehensive testing approach. Section 3.1 attempts to cover all the various considerations and offers up important guidelines and testing requirements that may need to be followed. While reading this section, please keep in mind that much of what is discussed may not apply to your situation.

**Note: To help our customers get up and running with the LCA as quickly as possible, we recommend you fill out the questionnaire located in the back of this manual and email or fax back to at us 770-447-0889 or chemtrac@chemtrac.com. Once your information is received, a product application expert will review the info and contact you with your personalized recommended testing procedure. Otherwise, there is a good deal of information contained in this section of the manual to help get started with the LCA. A good understanding coagulation chemistry and theory will aid in one's understanding of much of the information provided here.**

**Note: Coagulant dosage may need to be higher or lower than what is determined using the LCA. The LCA is intended to be used as a support and not a replacement for experienced water treatment operators, The LCA is especially useful as an aid to optimizing and lending support to Jar testing. It is highly recommended to verify LCA results using Jar Testing.**

### 3.1.2 The Difference Between Online and Lab Charge (Streaming Current) Measurement

Some users will be familiar with, or perhaps operate, an online Streaming Current monitor and want to know how the LCA differs and whether it's reading should match the online SCM. This section explains the differences and why the LCA reading can sometimes be very different from the online SCM.

The LCA utilizes streaming current technology, but its application and response to coagulant can be very different from online streaming current (SC) measurement devices. Online SC devices are extremely useful for monitoring water quality changes that impact coagulation, and even controlling coagulant dosage when conditions allow. But a limitation of online SC devices is that they provide a "relative" measurement of charge due to how certain factors like pH and lag time can impact the reading and cause the optimum charge value, or setpoint, to always be subject to change. The specific set of conditions required for the optimum charge value to remain consistent and predictable are more easily obtained with laboratory measurement of charge, and so the LCA provides a more accurate measurement of charge.

The main factors that allow the LCA to more accurately measure charge, as compared to online SC devices, include:

1. Ability to maintain the optimum pH range for charge measurement to ensure best response to a given coagulant. This optimum pH range is coagulant specific. With online SC devices the sample pH may be higher than the ideal range for charge measurement accuracy, or the pH may be swing widely from one day to the next. High pH values will cause online SC readings to appear less responsive to the coagulant, and unstable pH will cause the online SC readings to also appear unstable. With the LCA, the sample pH can be tightly controlled so as to remove the adverse

impact that pH can otherwise have on charge readings.

2. Measurements taken with the LCA are being performed at the exact moment coagulant is being introduced. This is very important because the charge as measured by SC devices will move in the negative direction with time due to insoluble aluminum (or ferric) hydroxide formation. The LCA's ability to measure the sample immediately upon coagulant addition when soluble and colloidal species of coagulant are most present allows those species to be available to interact with negatively charged species adsorbed onto the sensor's surfaces. This provides a more accurate determination of the dosage needed for charge neutralization as compared to an online SC device which is typically >30 seconds downstream of coagulant addition and potentially past the point where the coagulant has more substantially precipitated into its insoluble form which has a reduced ionic charge.

3. Ability to maintain a clean sensor. With the LCA, the sensor is cleaned between each titration, ensuring the measurement surfaces are never fouled and this ensures greater measurement accuracy. With online SC devices, there is always some degree of fouling which can lead to an offset in the charge readings.

For the reasons just described, it is very important to understand that the LCA's reading will not match up with an online SC reading except under very specific conditions. In order to compare LCA to online SC readings, the online and lab SC devices would need to operate under the exact same sampling conditions. For example, after cleaning and then calibrating the readings to match on a raw water sample, the lab unit could be used to compare against and verify the online SC instrument, but it would require taking a continuous flowing sample to the lab unit (e.g. into the beaker and letting it overflow) with the same approximate lag time as the online unit. Under these conditions, both the online and lab unit should provide a comparative response to treated water charge.

### 3.1.3 Why the LCA is Not Always the Right Tool for Determining Coagulant Dosage

In simplest terms possible, whether or not the LCA is the right tool for a given water treatment application depends primarily on how critical or not charge neutralization is to obtaining the desired treatment outcomes. To understand if the LCA is the right tool, one needs to consider the mechanisms of coagulation and which ones are at play and necessary to achieving acceptable treatment results. This is largely determined by type of coagulant and dosage being used, water chemistry (pH, alkalinity, TDS, temperature), and water quality (turbidity, total organic carbon).

**Note: Determining whether charge neutralization is a critical coagulation mechanism for any specific application is a complex topic which cannot be fully dealt with in this manual. It is recommended to speak with an application specialist to get the most accurate assessment for your unique application.**

Charge neutralization is the coagulation mechanism that the LCA is designed to measure. A common incorrect assumption is that you cannot have "acceptable" coagulation results unless charge is brought close to neutral. The reason why charge neutralization isn't always necessary is because of another very important mechanism associated with inorganic coagulants, which is the "Sweep Floc" mechanism. This mechanism can metaphorically be viewed as casting a net into the water to capture particulate. When an inorganic coagulant like Alum is introduced into water, it will form insoluble precipitate which is often referred to as chemical floc or sweep floc. Sweep floc can work fairly well on its own to enmesh and adsorb particulate, allowing that particulate to be settled and more easily filtered, all without ever needing to bring a colloid's charge to neutral.

There are potential limitations, however, to what Sweep Floc coagulation can achieve on its own. The soluble cationic species necessary for charge neutralization can greatly benefit filter performance and TOC reduction. For this reason, the overall best treatment results are very often only obtained with a combination of charge neutralization and sweep floc mechanisms. More often than not the two mechanisms are working

together, and that is the situation where the LCA is the right tool.

In some applications, a WTP may find that during the drier months of the year they are running at a slightly higher pH and alkalinity, while at the same experiencing favorable raw water quality (e.g. low NTU and TOC). During these conditions, the WTP is more likely to be able to operate in a sweep floc coagulation mode and not be required to achieve charge neutralization. A test on the LCA under these conditions may produce a dosage result that is higher than what the WTP finds to be necessary. But during the wetter months the alkalinity and pH may be slightly lower while at the same time NTU and TOC are higher. Under these conditions, the charge neutralization mechanism will often become more critical and the LCA is much more likely to prove very useful in determining an optimum coagulant dosage.

### 3.1.4 Organics Impact Charge and Dosage

For a given mass, organics will exhibit a higher anionic charge than turbidity and potentially be a more significant determining factor in how much coagulant is needed to reach charge neutralization. Said another way, the sample being tested with the LCA will only reach a neutral charge when both turbidity and organics are neutralized with a sufficient dosage of coagulant.

Charge neutralization can be especially critical in applications looking to obtain maximum TOC reduction in order reduce disinfection byproducts to the greatest extent possible.

### 3.1.5 Potential Impact of Higher TDS and Inorganic Anions

As a general rule, waters with low NTU and TOC and higher total dissolved solids (TDS) of >100 mg/l are more likely to see LCA dosage results that are in excess of what is actually required for acceptable treatment. Under these conditions, a dosage that achieves full neutralization can be in excess of the dosage required for adequate sweep floc formation. This is especially true when the sample contains elevated levels of stronger anions like Sulfate or Phosphate. These inorganic anions can significantly increase the amount of coagulant required to reach neutral charge on the LCA, well beyond the “sweep floc” dosage that may provide acceptable treatment dosage results for NTU reduction.

### 3.1.6 Flocculant and Coagulant Aides

The LCA will allow the user to also test out various options in terms of coagulant dosage in ratio to other chemicals which impact charge (namely flocculants and coagulant aides). For example, the user may find that 0.5 ppm of flocculant along with 25 ppm of Alum brings the sample to neutral. A second test using 1 ppm of flocculant only requires 22 ppm of alum to reach neutral. And a third test using 1.5 ppm of flocculant only requires 19 pm of alum to reach neutral. All three of these dosing options bring the sample to a neutral charge, but one of them will likely have better outcomes in terms of floc formation, settling, filterability, NTU and TOC reduction, etc., all of which can be evaluated with jar testing once the dosages are determined by the LCA.

One of the more confusing aspects to many new users of the LCA is the recommendation that a flocculant or coagulant aid (like a DADMAC polymer) be fed to the LCA’s sample prior to the coagulant being introduced. This is confusing because these chemicals are generally fed downstream of coagulant in the full-scale process and when conducting conventional jar testing the flocculant is usually added after the coagulant has been allowed a short rapid mix period. The reason flocculant is fed first is because an anionic or cationic polymer can impact the sample’s charge and resulting coagulant demand, and/or it can favorably impact the responsiveness of the LCA to the coagulant. In other words, the flocculant will often impact how much coagulant is needed to reach neutral, thus it must be fed into the sample before the coagulant so that an accurate dosage assessment can be made.

The recommendation is to do the testing with and without the flocculant or coagulant aid because in some cases it will make little to no difference to the titration results. And in cases where it does have an impact on the coagulant dosage, testing can be done to see if the result is linear and repeatable. For example, it may be seen that 1 ppm of a given cationic flocculant will consistently reduce the amount of coagulant needed to reach neutral by 5 ppm and 0.5 ppm of flocculant reduces coagulant by 2.5 ppm. If the result is found to be linear and repeatable, then the user can bypass feeding the flocculant and simply factor it into the results by subtracting the appropriate ppm dosage from the coagulant

titration result to account for the flocculant dosage being used.

### 3.1.7 Oxidants (Chlorine, Ozone, etc.)

Any oxidants used in the coagulation process (prior to clarification), like ozone or chlorine, will need to be fed to the sample prior to coagulant addition. Failure to do so may cause a significant increase in the dosage of coagulant required to neutralize a raw water sample. For most oxidants like chlorine and chlorine dioxide, it is recommended to allow for a 10 to 20-minute contact time before titrating the samples with coagulant. If the oxidant is not provided this contact time, the sample may exhibit higher coagulant demand. Testing samples at 10-minute intervals can help determine what length of contact time is required. Contact time needed for ozone is very short by comparison.

### 3.1.8 Possible Concerns with Coagulant Dilution

With certain coagulants like lower basicity PACl the user is recommended to avoid any dilution of the coagulant, both in the full-scale process and when doing jar testing. Diluting these coagulants can result in significant error in coagulant dosage determination using the LCA. Check with chemical supplier to see if dilution is acceptable, and also try comparing testing results on the LCA feeding the coagulants both undiluted (neat) and diluted to see how much dilution impacts the required dosage to reach neutral charge. It is also recommended to test an older diluted sample to a fresh one in order to help determine the shelf life of a diluted coagulant.

When making a dilute solution of coagulant, it is very important to first understand how the coagulant dosage is being calculated in the full-scale process. This is necessary to understand in order to make an accurate dilution which ensures the LCA dosage results are being calculated the exact same way as the full-scale process. Making a proper 1% solution can be very confusing and prone to mistakes due to there being e a few different ways coagulant dosage is calculated: (1) As liquid product by volume, (2) As liquid product by weight, (3) As active ingredient. For Alum, most users consider the active ingredient to be “dry aluminum sulfate”, but others may calculate their dosage as “aluminum oxide” or “aluminum ion”.

Contact an application specialist at Chemtrac for assistance with determining coagulant dosage calculation and dilution procedure.

**Note: In cases where dilution of the coagulant is not possible or desired, Chemtrac does offer an option for a Syringe Pump. Units not originally outfitted with the syringe pump can be upgraded to have this option.**

### 3.1.9 Addition Rate of Coagulant

It is important that coagulant is added in a timely manner to the LCA’s sample, but not so quickly as to cause overshoot of the neutral endpoint. It is not always possible, nor is it necessary, to bring the charge reading right exactly zero. Getting to within +/- 5 units is usually fine. It is also not required to have the charge stay right close to zero after the neutral endpoint is reached. Charge will often slowly drift negative with time. For this reason, it is not recommended to titrate slowly or to wait for the reading to fully stabilize before adding more coagulant.

The basic procedure for titrating the coagulant into the sample is to add at least 50% of the expected coagulant dosage all at once and then start incrementally adding additional coagulant to the sample to bring the charge to zero within 5 minutes (3 to 4 minutes is ideal, 2 minutes or less is likely too fast and will cause overshoot). Do not wait for the reading to fully stabilize before adding more coagulant, and do not be too concerned with a 5 to even 10-unit overshoot of the endpoint. Experimentation and experience with the rate of titration is necessary in order to achieve accurate and repeatable results. Models with automatic titration capability will ensure the coagulant titration is performed in the proper time span and with minimum overshooting.

### 3.1.10 Tips When Using Micropipette

Whether it is a preference or requirement to feed certain chemicals neat (undiluted) to the sample, certain precautions need to be taken in order to obtain accurate and repeatable results. It is important to pay attention to the pipette to make sure chemical is actually flowing into the pipette when filling (use fresh tips with each test to avoid tip plugging), and that there are not bubbles or air pockets in the pipette tip. Care should also be taken to ensure the tip is free of any droplets that

may hang onto the outside surface. Be careful about wiping the pipette tip against a cloth or paper towel to remove droplets as this can wick some of the coagulant out of the tip. A fast swipe with a cloth is needed to wipe away droplets.

When injecting the coagulant into the sample, point the pipette tip away from the sensor opening to avoid having too high of a concentration of coagulant going directly into the sensor before a bit of mixing has time to occur. If coagulant goes into the sensor opening at a high concentration, this can cause the reading to climb very quickly towards zero and then swing back down rapidly and make managing the titration rate a bit more difficult. If the pipette tip is free of visible droplets of neat coagulant, it is generally OK to submerge the tip below the sample surface, but care needs to be taken when doing so because any coagulant on the outside surface of the tip will cause error in the dosage determination.

### 3.1.11 Importance of pH to Charge Readings

When using inorganic coagulants, consideration must be given to sample pH when conducting titrations on the LCA. If titrations with a given coagulant like Alum are conducted on the LCA at a pH that is too high for that coagulant, the LCA will exhibit a much smaller response to the coagulant and require an excessively high dosage to reach a neutral endpoint.

As seen in figure 7 (which is only specific to aluminum sulfate), the pH of the sample after coagulant addition determines which metal hydroxide species are present in equilibrium, and what their respective concentration will be. In order for an optimum dosage of coagulant to bring the LCA's sample charge to neutral, the coagulant must have a sufficient cationic charge density. The charge density is determined by the concentration of cationic metal hydroxide species (e.g. $Al(OH)^{2+}$), which varies depending upon pH.

The net cationic (positive) charge of the metal hydroxide species is highest at lower pH's (e.g. <6.5 for Alum). At pH >7.0, Alum's cationic charge is very low due to the anion $Al(OH)_4^-$ being the predominant dissolved aluminum species and will have a greatly reduced impact on the LCA's charge readings even at optimum dosages that produce acceptable results for the treatment process. In order to improve the response to Alum and obtain more accurate results on the LCA, the sample pH ideally needs to be in the optimum range (e.g. typically 6.2 to 6.7 when titrating with Alum). Each coagulant has a unique profile and a specific pH that is optimum for charge neutralization measurements.

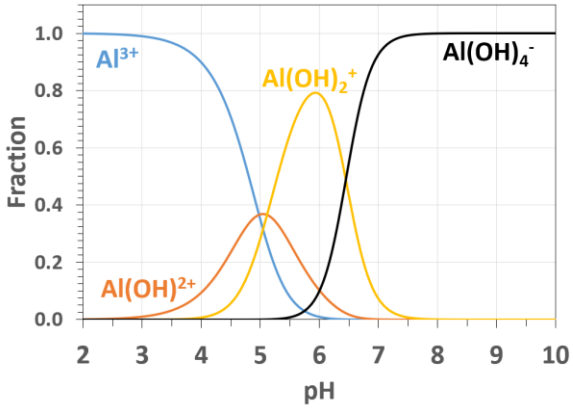



**Figure 7 – Al-OH Species vs pH (Alum)**

When the pH is found to be too high for a given coagulant, the recommendation is to feed acetic acid to the sample to reduce the pH to what has been determined to be an optimum range for that coagulant. The reduction in pH to an optimum range will ensure the sufficient availability of cationic aluminum species like $Al(OH)_2^+$ and $Al(OH)^{2+}$ that are necessary to conducting meaningful charge neutralization measurements for the purpose of determining an optimum coagulant dosage. This resulting dosage will in many cases be an optimum dosage for the process.

The below table is intended as a general guide to help the user identify if reduction to the LCA's sample pH is required.

| Coagulant | Optimum pH | pH Limit |
|---|---|---|
| Alum | 6.5 | 6.8 |
| Ferric | 5.5 | 5.8 |
| ACH | 7.5 | 7.8 |
| HB PACl | 7.2* | 7.5* |
| MB PACl | 6.8* | 7.1* |
| LB PACl | 6.5* | 6.8* |

*These pH targets can vary widely depending on compounds blended with the PACl coagulant. Example: If Sulfate is listed on MSDS of PACl coagulant, it may be necessary to drop the values in this table by 0.5 units.

**Figure 8 – Examples of Various Coagulant's Optimum pH for Charge Measurement**

If using one of these coagulants, check to see if the process pH measured after coagulant addition is above the "pH Limit". If the process pH is above the limit, then pH reduction of the LCA's sample will likely be required. Use acetic acid to reduce the sample pH down to at least the "pH Limit" value before titrating the sample with the coagulant. Once the titration to a neutral endpoint is completed, the ending pH is measured and recorded along with the dosage result. Small adjustments can be made to the starting pH to determine whether a slightly higher or lower ending pH produces a more optimum result. The "Optimum pH" value shown in the table is the ending pH which have typically been shown to provide the the most optimum dosage result. But in some cases, it will be necessary to target a slightly lower or higher ending pH which is usually within +/-0.3 units of what is shown in the table.

**Note: It is recommended to only use acetic acid to reduce sample pH. Other acids, like sulfuric acid, can contribute anions which increase the coagulant dosage needed to obtain neutral charge. The only time an acid like sulfuric acid should be used is when that same acid is also used in the process for suppression of coagulation pH. If wanting to use a different acid like HCl, the recommendation is to compare the results obtained with acetic acid. If the results are comparable, the alternative acid should be OK to use.**

**Note: When feeding an acid to lower the sample pH, keep in mind that it is possible to lower the pH too far. Doing so will cause the LCA dosage result to also be too low.**

**Note: The optimum pH for charge measurement should not be confused with the optimum pH necessary to achieve acceptable treatment outcomes in the full-scale process. The two have no direct dependency on each other. Optimum pH for charge measurement is simply just the pH necessary to ensure availability of soluble cationic species that allow the LCA to perform accurate end point titrations**

### 3.1.12 Procedure to Determine or Verify Optimum Sample pH for LCA Testing

**Note: It is recommended to contact Chemtrac and speak with an application specialist before doing the testing described in this section. Specific details about the coagulant being used and the treatment process will be requested (see questionnaire at the back of this manual). This information will allow the specialist to make time saving recommendations regarding sample pH.**

Waters with moderate to high alkalinity, and especially those being treated with Ferric, Alum, or lower basicity PACl, are more likely to require sample pH reduction in order to ensure a good response to the coagulant. The optimum pH range for conducting testing on the LCA with Alum, Ferric, and ACH is well established (see previous section). For other types of coagulants, contact Chemtrac to see if there is a pH recommendation available for the coagulant being tested. Otherwise, it may be necessary to perform the test procedure provided here in order to identify the optimum pH.

Once determined, the user will then be able to quickly adjust the sample pH when necessary so as to achieve a more accurate coagulant dosage result on the LCA.

Procedure for determining optimum ending pH range for LCA testing with any coagulant:

1. Before performing this procedure review section 3.2 and follow the guidance on conducting LCA titrations up to section 3.2.4.
2. Determine an optimum coagulant dosage. This should be the minimum coagulant dosage required to achieve optimum treatment results. Special emphasis should be given to TOC reduction and unit filter run volume (UFRV) or filter runtime if UFRV is not calculated. While settled NTU is important, users will sometimes find that dosage required for low settled NTU target is higher than the coagulant dosage required to achieve good UFRV's and TOC reduction. In other words, while low settled NTU is desirable, it is not always a reliable predictor of an optimum dosage as defined by filter performance, organics reduction, no more sludge generation than is necessary, and overall treatment cost. Because charge is more important to UFRV and TOC reduction,

these are the recommended parameters to use when determining an optimum dosage for this testing.

3. Collect at least 2 to 3 gallons of raw water for testing on the LCA (see section 3.2.1). If an oxidant like chlorine is used in the process, be sure to allow the sample to have 15 to 20 minutes of contact time with the oxidant before beginning testing.
4. Fill a 1-liter sample beaker with raw water. Introduce any other treatment chemicals used in the coagulation process (e.g. flocculant) that are not already contained in the raw water sample (see section 3.2.2). Be sure all chemicals are fed at the same dosages as used in the process.
5. Record the SCV and pH of the sample before coagulant addition (record as the "starting pH"). Titrate the sample with the previously determined optimum dosage of coagulant.
6. Note the SCV and pH after coagulant addition (record as the "ending pH"). If the LCA charge reading is negative but within 10 units of zero, or if the reading is positive, then the current sample ending pH is deemed most likely appropriate for LCA testing, and this ending pH should be targeted on future titrations.
7. Repeat steps 4 to 6 but reduce the sample pH with acetic acid before titrating with coagulant. The pH should be reduced by 0.2 to 0.5 units depending upon how far away the LCA reading was from neutral on the previous test. Be sure to record the pH after acetic acid addition as the "starting pH".
8. Repeat steps 4 to 7 to identify the ending pH where the optimum dosage brings the LCA charge reading closest to neutral is determined. Be sure to record the ending pH after each coagulant addition as the is the critical pH to identify.
9. Once the optimum ending pH is determined using this procedure, the user is recommended to target that same ending pH on all future testing (+/-0.2) in order to achieve accurate results.

It is highly recommended to compare the LCA results to jar testing for an appropriate period of time to verify accuracy of this procedure under various water chemistry and water quality conditions in order to determine if the ending pH that has been identified with this procedure is optimum for all various conditions experienced.

### 3.1.13 Determining Optimum Dosage of Base (e.g. Caustic, Lime)

When treating source waters with lower alkalinity and especially when feeding an acidic coagulant like alum or ferric, it may be necessary for the WTP to also feed a base (e.g. caustic or lime with negative charge) to maintain sufficient alkalinity and an optimum pH for coagulation. In these cases, the LCA is an excellent tool to help an operator not only determine the required dosage of a coagulant, but also determine the optimum dosage of a base that is fed to the coagulation process. The LCA performs extremely well when the plant's coagulation pH is also optimum for charge neutralization. The optimum pH is dependent on the coagulant being used. For Alum, a pH less than 6.7 works well for the LCA due to the coagulant having a higher cationic (positive) charge density in this pH range. Whereas Ferric would require a pH <6.0 in order to achieve acceptable dosage results on the LCA. The LCA will always titrate to the lowest possible coagulant dose within a pH range that works best for the coagulant in regard to charge neutralization. As long as the full-scale process coagulation pH is in an acceptable range, one that doesn't inhibit the coagulants cationic charge, the recommendation is to target the same pH on the LCA.

There are many cases, however, where a base is being used to raise coagulation pH above the range that is optimum for charge neutralization to occur (see sections 3.1.10 and 3.1.11), and this is sometimes due to needing to meet more stringent optimization goals around sedimentation turbidity. Feeding a higher dosage of caustic (a base with negative charge) allows for higher dosages of coagulant to also be used. This in turn produces additional sweep floc which helps further reduce sedimentation turbidity levels below that which would be possible at a lower coagulant dose and a lower coagulation pH. The consequence of using higher dosages of these chemicals is more solids generation and higher treatment cost. This approach can also lead to reduced filter run times, longer backwash cycles and higher residuals in the finished water. The LCA as a dosage optimization tool becomes less reliable with a sweep floc approach due to the fact that the optimum dosage is based less on charge neutralization and more on excessive floc formation necessary to reduce settled NTU to exceedingly low levels which may arguably not be

necessary to achieve the desired treatment outcomes.

The only practical way to try and utilize the LCA in this scenario is to experiment with titrating at lower pH's and see how that compares to full scale coagulant dosage that is needed to achieve desired treatment goals. In the case of Alum, the user is recommended to target a pH no higher than 7.0, keeping in mind that a higher target pH will result in a higher dosage of Alum and base being required to reach neutral. Some users have found that the Alum dosage achieved at a target pH of 6.8 on the LCA gave good agreement with what proved to be the necessary dosage of Alum needed to achieve their sedimentation turbidity goal in the full-scale process. Ferric usually requires the LCA's target pH be no higher than 6.0 and so a user may experiment with target pH's between 5.5 to 6.0. It is highly recommended to seek guidance from an application specialist at Chemtrac before beginning use of the LCA under this scenario, and to conduct extensive testing to verify the validity of the LCA testing results.

**Note: In order to obtain accurate results when titrating with a base, it is critically important that the pH probe be accurate and responsive. The LCA pH probe will foul more quickly due to direct exposure to the coagulant in its more reactive phase. This will cause the pH probe to become more sluggish and less accurate. The Slope value (displayed after a pH calibration is performed) is a good indication of probe health. If the Slope is <57.0 mV, the response and accuracy will be impacted and may cause the LCA titration results to also be less accurate. Slope of 56.5 mV is considered too low to achieve accurate results on the LCA. It is recommended to routinely soak the pH probe in 0.1 to 0.3 N HCL as this helps dissolve away metal hydroxide deposits which foul the probe. A short 10 to 30 second soak after each titration can be very effective at maximizing the pH probe's useful life**.

#### 3.1.14 Considerations When Using Base to Raise Sample pH

If it becomes necessary to feed a base (lime/caustic) to maintain the target pH, the base should ideally be added during the titration procedure, and only after the pH has dropped 0.3 to 0.5 pH units below the target. Once the pH drops this amount, proceed with adding the base and raise the pH to within 0.1 of the target pH, taking care to not overshoot the target pH. Overshooting the target pH with base will result in having to feed more coagulant then would otherwise be necessary to reach the neutral endpoint. Continue adding coagulant, and base as necessary, until the neutral endpoint is reached at a pH value that is at least within 0.1 units of the target pH.

**Note: The addition of the base can be fully automated with the LCA-3.**

## 3.2 Basic Testing Procedure

It is recommended to clean the LCA Sensor and sample beaker as detailed in section 4.2 of this manual before conducting a titration.

If using the LCA's automatic titration features, it is recommended to prime and calibrate the titrant pumps as described in section 2.2.3 of this manual to ensure proper operation. Note: If using the optional syringe pump, it is very important to review the instructions provided in section 2.2.4 to ensure proper operation of the pump as tiny air bubbles and possible crystallization of the coagulant can cause significant error in the results.

If using the LCA's pH probe, be sure to calibrate the pH probe daily and keep an eye on the pH Slope result displayed after calibration (the slope from the last calibration can also be reviewed any time by pressing the down arrow on the display until the Status screen appears). Ideally the probe's slope value will be >57 mV. If the value is lower than 57 mV, cleaning and testing of the pH probe to measure response time and accuracy is recommended (see section 4.5 pH Probe Maintenance).

#### 3.2.1 Collect Raw Water Sample

It is recommended to use a minimum sample volume of 1000 ml (or whatever sample size is being used in the plant's jar testing device to make dosage calculations equivalent). Collect enough sample to perform at least two tests. When collecting a sample for analysis with the LCA, observe these important guidelines:

- The sample must be taken upstream of coagulant addition and not contain any coagulant.

- The sample should be taken ahead of the addition of any pH adjustment chemicals like lime or caustic if fed to the coagulation process. This is necessary because the optimum pH for the LCA test may look different from the pH value that is being maintained for the water treatment process. But even if pH targets are the same for both, it is best to feed the coagulant first and only add lime/caustic as needed to maintain pH at the target pH. In this way, an accurate dosage of both coagulant and base can be determined.

- All other chemicals that are fed to the coagulation process (chlorine, potassium permanganate, coagulant aids, flocculants, powdered activated carbon, etc.) need to be included in the sample that is tested on the LCA. This is especially true of any oxidant fed ahead of or immediately following coagulant addition.

- Look to see if a sample point exists that allows for the collection of a sample that has one or more of the treatment chemicals already present. This can save time in preparing a sample for testing. Some chemicals will be fed at the same location or downstream of the coagulant and will therefore have to be manually introduced after the sample is collected, making sure those chemicals are introduced at the same dosage as what is being fed to the process.

  When collecting a sample that contains some of the process additives, ensure it is at a point where adequate mixing/distribution of those chemicals has occurred. If in doubt, or if LCA testing proves to be not very repeatable, it is advised to grab a raw water sample without any treatment chemicals and then manually add those chemicals to the jar to ensure proper dosages of those chemicals is obtained.

### 3.2.2 Prepare Sample for Testing

Add any remaining treatment chemicals used in the process that are not already contained in the sample (e.g. flocculant). Do not yet add the coagulant or chemicals such as caustic that are used to adjust coagulation pH. Coagulant (and if necessary, lime/caustic) will be added during the sample titration phase. As discussed in section 3.1.5, it is recommended to go ahead and feed flocculant (if used) to the sample prior to submerging the sensor in the sample. Ensure the sample is being mixed with the magnetic stirrer while chemicals are being added.

***NOTE***: Experimentation is recommended to see if other treatment chemicals used in the process, like flocculants, have any impact on the testing results, or if the impact is repeatable enough across various sample conditions to allow the exclusion of that process additive from future testing. For example, if a cationic flocculant fed at 0.5 ppm is found to reduce the demand for coagulant by 3 ppm across a wide range of samples (with various NTU and TOC levels), then the flocculant can be excluded from testing and the operator would just subtract 3 ppm from the testing result to account for the flocculants portion of charge neutralization.

### 3.2.3 Positioning Sensor into Sample

Positioning the sensor into the sample requires raising and lowering the LCA stand. The adjustment capability of the stand allows the user to incorporate a wide range of beaker sizes.

To raise the stand, first grip the handle and push the release button. While continuing to hold the button down, use a lifting motion to raise the stand (Note: slightly push down on the top of the LCA while pressing the release button if it is difficult to get to rise. This will get the lift mechanism to release). After raising the stand, place the sample beaker under the sensor and then lower the stand by pressing the stand release button and then applying pressure to top of LCA to lower the sensor into the beaker. Once the opening on the side of the sensor is just below the sample surface (as shown in Figure 6), release the button and the stand will stay locked in place.

**Warning: Be sure to not submerge the sensor below the thumbscrew on the front of the probe!! This will cause inaccurate readings and lead to corrosion of the electrical connections.**

As shown in Figure 6, submerge the probe so that the sample comes up to the openings in the probe. Sample should cover the hole halfway or be just at the top of the hole. Do not lower the stand so far such that the sample reaches the metal clip which latches the probe in place.

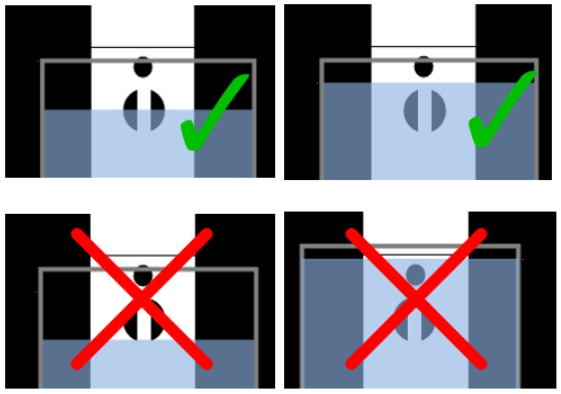


Figure 9 – Optimum Depth of Probe in Sample

### 3.2.4 Sensor Conditioning & Stabilization

If performing a manual titration, turn the motor on by pressing the START MOTOR button. Allow at least 1 minute for the sensor to condition and the reading to stabilize before adding coagulant. While the reading is stabilizing, take time to ensure all the other necessary treatment chemicals (e.g. chlorine, flocculant) have been added to the sample at the proper dosages.

### 3.2.5 Sample pH Reduction (If Necessary)

As discussed in section 3.1.10 and 3.1.11, it may at times be necessary to reduce the sample pH to an optimum range prior to titrating the sample with coagulant. This needs to be done prior to titrating the coagulant into the sample.

### 3.2.6 Manual Titration Procedure

With the completion of the previously discussed steps, the sample is ready to be titrated with the

coagulant. If titrating manually, add the coagulant in incremental dosages until the neutral endpoint is obtained. The target time to titrate the sample to a neutral charge should be 2 to 5 minutes. Figure 7 shows an example of how the incremental dosages and resulting charge response may appear. The first dose fed to the sample when doing manual titrations should be at least 50% to 75% of the expected dosage. Then smaller incremental additions should be made from that point until neutral charge is reached.

Once the neutral endpoint is reached (at the target pH), the test is complete. Simply determine what volume of coagulant was required to reach neutral and calculate the parts per million (ppm) or mg/l dosage.

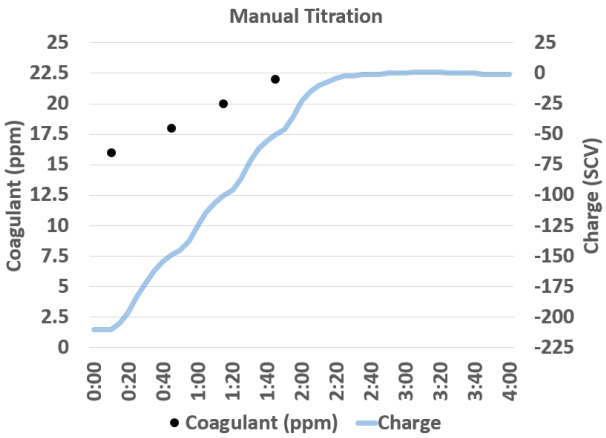



Figure 10 – Manual Titration

### 3.2.7 Automatic Titration Procedure

If using LCA5 models with built in titrant pumps, the coagulant titration can be performed automatically when using dilute coagulant solutions, or neat solution with the optional syringe pump. It will be necessary to first program the Titration controls as outlined in section 2.1.1, as well as the pH Titration controls as outlined in section 2.1.2 if using an LCA-3.

Once programmed, the titration can be started by pressing the “Titrate” button. The titration profile will appear similar to what the graph illustrates below. Each dot on the graph represents a single pump stroke of the titrant pump. Each stroke dispenses approximately 50 µl of coagulant, which works out to 0.5 ppm per stroke dosage if using a 1% solution of coagulant and 1,000 ml sample size.

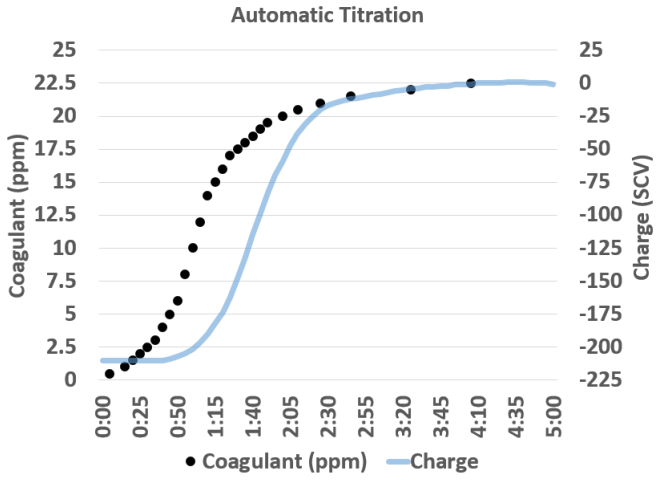



Figure 11 – Automatic Titration

**Note: Coagulant dosage may need to be higher or lower than what is determined using the LCA. The LCA is intended to be used as a support and not a replacement for experienced water treatment operators, The LCA is especially useful as an aid to optimizing and lending support to Jar testing. It is highly recommended to verify LCA results using Jar Testing.**

# 4. Maintenance

## 4.1 Signal Health Readout

Located on the front display is a percent (%) readout labeled “SH” which stands for signal health. The signal health readout is diagnostic analysis of the streaming current waveform that is generated by the sensor. This signal is an approximate 4 hertz sine wave. If the signal has a near perfect sinusoidal shape, then the signal health readout will be 100%. The signal health readout is only valid when the LCA reading is sufficiently anionic or cationic in value. If the LCA reading is within +/- 30 units of zero, the signal becomes very small and meaningful analysis of the waveform is no longer possible. Therefore, the signal health readout should be evaluated prior to starting the titration to ensure it is better than 90%.

If the signal health is below 90% when getting ready to start a titration, press the Menu button to enter the menu and then press the Menu button again to exit the menu. This resets the analyzer and will sometimes fix a corrupt signal health valve.

The signal health will drop below 90% for the following reasons:

- **Sensor is fouled**. Certain types of sensor fouling can cause the signal to be unstable. Anytime the signal health is erratic or falling below 90%, it is recommended to first try cleaning the probe and piston **Note**: A signal health reading of >90% does not indicate the probe is clean and does not require cleaning. The sensor can be fouled or have a residual substance impacting the measurement results and still exhibit a 100% signal health. If tests results do not seem accurate or repeatable, always try cleaning the probe and piston as the first troubleshooting step.
- **Too high of solids in the sample**. A disrupted signal health is especially likely if there are larger solids, like fibers, or substances like greases in the sample. If the signal health is near or below 90% and/or the reading appears unstable, it is recommended to strain out the larger solids using a 200 mesh (74 micron) or finer screen. Particles >10 micron generally do not contribute in any meaningful way to the charge reading or the titration result.
- **Loose motion in drive linkage.** After long term or heavy use, the LCA’s motor or drive linkage may begin to wear down and cause unstable motion in the piston. This will cause the signal health value to drop and indicate factory maintenance of the motor or drive linkage assembly is required. To prevent premature wear on the drive linkage, it is best to only run the LCA motor as needed and not leave running on a continuous basis.
- **Electrical Interference.** A strong enough source of electromagnetic interference (EMI) in close vicinity of the LCA could potentially disrupt the signal and cause unstable readings and changes in the signal health readout.

## 4.2 LCA Sensor Cleaning

The cleaning method and frequency of the LCA sensor will depend on the application. Cleaning is generally recommended between each test. Through comparative testing, some users may find that cleaning between each test is not necessary. However, cleaning is always recommended prior to using the LCA if its “last use” condition is unknown (e.g. a different operator had previously conducted testing on the LCA). **Once a day cleaning should be performed at a minimum.**

Avoid touching the portion of the piston that fits down inside the probe bore (between the electrodes), and it is recommended to not use towels to dry any surfaces of the piston or down inside the probe bore where the electrodes are located. A very tiny amount of residual substance transferred onto these measurement surfaces from a towel or finger can impact the test results.

### 4.2.1 Cleaning Procedure

1. Push the probe release tab and then pull down on the probe to detach.
2. Remove the piston by rotating counter clockwise (only touch the very top part of piston)
3. Take the parts to a sink where they can be brushed under running tap water using the supplied brush or any available plastic bristle brush. Note: make sure brush is clean and has not been used to brush anything besides the LCA probe and piston.

4. Brush all surfaces of the piston thoroughly and then rinse thoroughly with DI water and shake off excess.
5. Immediately reattach the piston to the LCA being careful to only touch the top portion of the piston.
6. Brush all the wetted surfaces of the probe. Pay close attention to brushing inside the probe's bore where the electrodes are located. Use the supplied brush or any clean plastic bristle brush that easily fits into the 0.5 in (13 mm) opening. **Warning**: Do not force a brush into the bore! **Note**: The plug in the bottom of the probe can be removed to facilitate a more thorough cleaning if necessary. Be careful to not lose O-ring located under the plug.
7. Thoroughly rinse probe with DI water. Shake off excess water. **Note**: **Use a towel to only dry top of probe around the gold contacts**. Do not dry the internal surfaces of probe.
8. Re-attach the probe onto the LCA.
9. Brush the sample beaker under running tap water and rinse with DI water and shake out excess water.

#### 4.2.2 Use of Approved Cleaners

Cleaning with a chemical is usually only required on an infrequent (e.g. weekly) basis to prevent the parts from staining, or if the sensor is exposed to a more tenancious chemical or an overdose of a chemical. Most residuals that are left on the sensor surfaces after conducting a titration are easily removed using the above procedure which just involves brushing parts under running tap water.

A recommended procedure for evaluating what level of cleaning an application requires is to conduct several titrations in a row of a static sample (e.g. sample collected in 5-gallon bucket) being sure to perform the above cleaning procedure between each test. If there is a "residual effect", the coagulant dosage result will typically drift in one direction with each successive test (e.g. taking slightly less coagulant to reach neutral with each successive test). If this appears to be occurring, try using an approved cleaner as part of the cleaning procedure. If this improves repeatability in the testing, then the cleaner is clearly required and should be incorporated into the routine cleaning procedure. **Note**: If a cleaner is used, it is important to rinse the parts thoroughly with tap water and then DI water to flush away as much of the residual cleaner as possible.

#### 4.2.3 List of Approved Cleaners for LCA Sensor

It is important the cleaner that is used is safe on Delrin plastic and 316 SS. The cleaner also needs to ideally rinse away easily and leave no (or minimum) residual. Avoid cleaners with dyes, fragrances, and other additives not necessary to cleaning performance.

Approved cleaners include:

- **Powder Cleanser**. Comet or Ajax brands are good for quickly removing most stains that tend to build up on the sensor surfaces over time. (Note: Always rinse parts thoroughly and discard first titration result after using this cleaner).
- **5% Acetic Acid with 3% Hydrogen Peroxide** (50/50), great for cleaning off iron/manganese (Note: Do not soak parts in this solution as long term exposure can degrade Delrin. Keep exposure time to <1 minute. Recommend to spray on, scrub, and then rinse off thoroughly.)
- **Oxalic acid**. Safe cleaner for removing iron and manganese. Safe for soaking.

## 4.3 Titrant Pump Maintenance / Troubleshooting (Optional)

Whenever the LCA will not be in use for an extended period of time (e.g. >2 weeks), it is recommended to flush titrant pump(s). To flush, place pump tubing in container of DI water and press the "Prime" button. Approximately 2.5 mL of DI water will be flushed through the pump. Leave the tubing and pump full of DI water. Leaving pump dry for an extended period may result in pump not being able to prime (unassisted) in the future.

If the titrant pump fails to prime and is not dispensing liquid, remove the blue tubing fittings from pump and inspect to see if the tubing is protruding too far past the cone fitting. If tubing sticks past cone fittings as seen in right hand image below, this can cause the pump to not prime. The tubing should be flush with the flat end of the cone fitting as seen in left hand image.

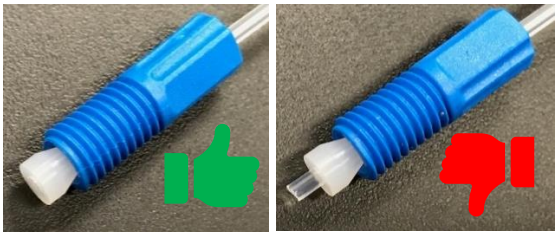


Figure 12 – Proper Assembly of Pump Fitting

Next, fill the LCA's accessory syringe (shown in below picture) with water and attach to the inlet port on the pump as shown. The inlet port is the one towards the middle, the outlet port is the one closest to outside edge. Once syringe is attached, start a pump prime by pressing the Prime button and then push down on the plunger to apply pressure to help prime the pump. Once pump is primed, reattach the fittings and test pump.

Figure 13 – Pump Priming with Accessory Syringe

If the pumps are not delivering a consistent volume when performing pump calibrations, it is recommended to first inspect and/or replace the pump tubing and fittings. Look for kinks in the tubing and/or air bubbles appearing in the tubing after an initial prime has been performed to remove air (one prime should be enough to remove all air from the lines). If kinks are found in tubing and/or if air continues to appear in the tubing, then install a new tubing kit. If replacement of the tubing and/or fittings does not resolve the performance issue, try flushing the pump with acetic acid or 0.1 to 0.3 N HCl. If these cleaners do not restore proper operation, contact the factory for assistance.

## 4.4 Syringe Pump Cleaning / Maintenance (LCA-2 & LCA-3 Only)

The optional Syringe Pump is used to inject Neat coagulant and is therefore potentially prone to plugging due to crystallization of the coagulant. It is recommended to flush out the syringe pump with DI water if it is not to be used for over 1 week to avoid plugging. Alternatively, the pump can be primed on a routine basis (daily to at least weekly) to avoid plugging. Greater caution needs to be exercised when using products that are known to have a limited shelf life like Polyaluminum Chloride (PACl). These coagulants can start to destabilize in days or weeks when exposed to air or moisture. With these types of coagulants, it is recommended to refresh the coagulant sample weekly in order to avoid plugging.

If the syringe pump does develop plugging, it typically occurs at the end of the tubing and most commonly at the injector but can also occur at other points in the syringe pump system.

Follow these instructions if plugging occurs.

1. Remove injector by unscrewing the black cap piece from the blue fitting. Be careful to not lose the small duck bill valve located inside the black fitting. Soak the blue tubing fitting and the black cap w/ duck bill valve in 0.1 to 0.3 N HCl for 1 hour to dissolve away crystalized coagulant. It is also advised to soak the tip of the inlet tubing in HCL as well.

2. Reassemble injector and ensure the tip of the duck bill valve is protruding out the bottom of the cap as shown in below image. Prime the pump to check if liquid is dispensed out the

injector. If there pump still fails to dispense, proceed to step 3. Otherwise, rinse off injector tip to remove any coagulant and the LCA is ready for testing.

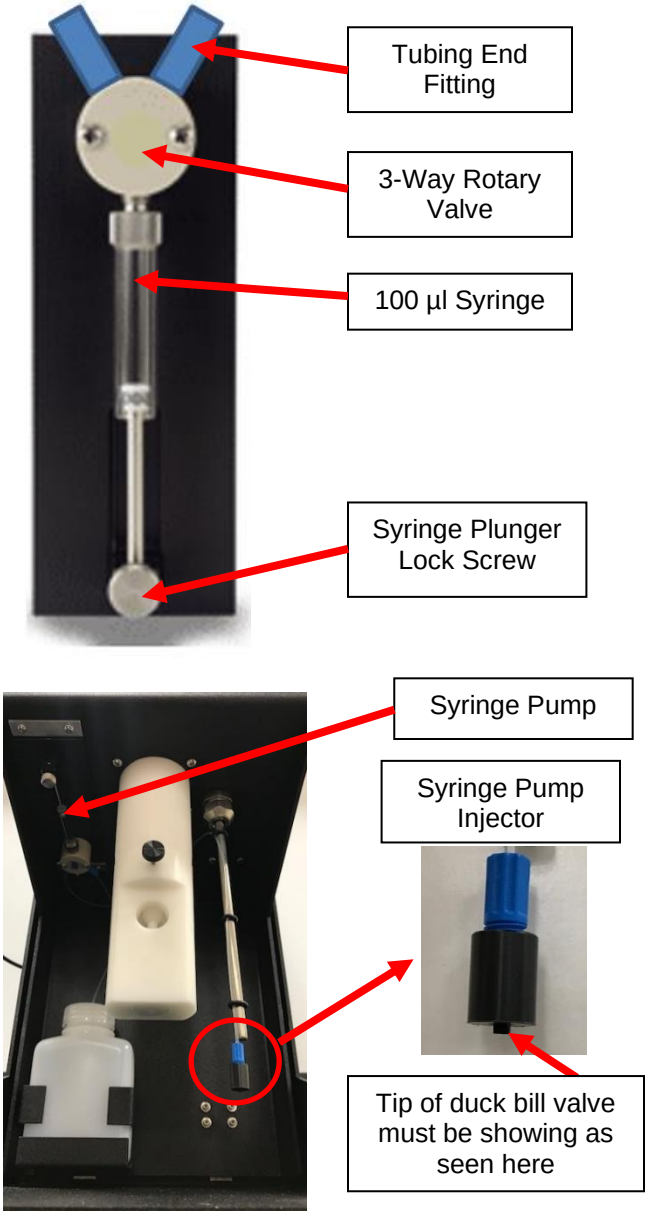



**Figure 14 – Optional Syringe Pump Assembly**

3. If step 2 did not resolve plugging, then remove the blue tubing fittings and syringe from the 3-way rotary valve. To remove the syringe, first loosen the syringe plunger lock screw and then push the plunger forward so it clears the armature. Then unscrew the syringe from valve by turning counterclockwise. Next remove the two metal Philips head screws on the rotary valve and pull down on the tan colored valve body to remove (Note: On the opposite side of the valve is a white plastic fitting. Leave this fitting in the current position to make reassembly easier).

4. Soak the rotary valve and the blue tubing end fittings in 0.1 to 0.3 N HCl for 1 hour. While soaking those items, test to see if the syringe is plugged by submerging tip of syringe in water and drawing back plunger to see if water can be pulled into and then ejected out of the syringe. If syringe is plugged, the remove the plunger and soak the syringe in HCl solution (Note: The HCl will darken the metal fittings on the syringe).

5. Start reassembly by first reattaching the blue fittings to the rotary valve. Next, slide the rotary valve back into position and reinsert and fully tighten the two screws to secure. Lastly, reattach the syringe to the valve and then pull back the plunger and ensure the tip goes as far back into the armature as possible. Finally, fully tighten the lock screw and ensure the plunger has no play (movement) in the armature.

6. Once reassembled, try to prime the syringe pump to see if plugging is resolved. If plugging is still not resolved, then the pump tubing will need to be replaced. Contact the factory for a new tubing kit.

## 4.5 pH Probe Maintenance

The LCA's pH probe can foul considerably faster than the typical laboratory pH probe due to the immediate, real-time exposure to coagulant during the initial reaction phase which may only last seconds to a few minutes after the coagulant is introduced. This type of exposure causes more rapid fouling which leads to error in the pH reading and produces a sluggish response, which can then lead to large errors with the LCA titration. This fouling will cause the pH slope to degrade to below 57 mV.

It is recommended to try and keep the slope >57 mV and to replace the pH probe when cleaning is no longer able to keep the slope >56.5 mV at an absolute minimum. Some users may find that 57.0 is a more reliable minimum slope by which to gauge whether the pH probe is due replacement. The pH slope is displayed after a pH calibration is performed and can also be accessed by pressing the down arrow to view the

Status screen. A 0.1 to 0.3 N Hydrochloric Acid (HCl) solution is the most effective cleaner to use on a routine basis to help mitigate this fouling.

Performing routine calibrations is the best way to gauge the rate of fouling, as evident by the speed and magnitude the slope value degrades, and to thereby determine the required frequency of cleaning.

The LCA's pH reading can also be compared to another laboratory pH analyzer to help gauge the probe's health in terms of accuracy and response time. It is often the case that the more sluggish responding pH probe is the least accurate (especially when comparing two liquid filled probes). Compare response time by placing both pH probes in pH 4 buffer for a few minutes, and then rinse both probes and place into sample of raw or treated water at the same time. Record the readings from both probes every 15 to 30 seconds until both readings have appeared to fully stabilize. If the LCA pH probe is noticeably slower to stabilize as compared to the other laboratory pH probe, and if the slope is <57.5 mV, then the LCA's pH probe is need of cleaning or replacement.

With proper maintenance, the pH probe should last one year and possibly up to 18 months.

Follow these use and maintenance guidelines to help ensure accurate and responsive pH readings:

1. Before each titration, peel back the silicon band from the vent/fill hole for just a second in order to allow the internal pressure to equalize. Leave the silicon band covering the fill/vent hole at all other times so as to avoid evaporation of the fill solution, which can lead to precipitation of KCl.

2. Remove the pH probe from the sample as soon as the titration is completed and rinse with DI water. It is recommended to also wipe the probe tip (bottom 1 inch surface) with a clean, wet soft cloth or cotton swab, or use a soft bristle brush to clean probe tip while spraying with DI water. After rinsing, immediately place probe back into pH electrode storage solution. Avoid letting the probe sit dry as this can result in the KCL solution crystalizing and temporarily plugging the junction.

3. Another recommendation is to soak the pH probe (bottom half) in 0.1 to 0.3 N HCl solution on a daily to weekly basis (when used) for minimum of 10 to 30 minutes, followed by a rinse with DI water and then placing probe in pH electrode storage solution. **NOTE**: If the slope drops down to 57 mV or lower, and especially if the response appears sluggish, then increase the frequency of these HCl soaks. In rare cases, a short HCl soak after each titration may be required to prevent the slope and response time from degrading.

4. Routinely top off the pH probe's electrolyte (fill) solution to keep the level within 1 cm of the fill/vent hole. This is required to maintain sufficient hydrostatic pressure which helps ensure maximum probe response time. Dump out the electrolyte solution and refill with fresh solution every one to two months.

An "advanced cleaning" may be necessary on occasion to restore the pH probe's slope and response time. The following steps are recommended for advanced cleaning:

1. Soak the probe for 10-15 minutes in clean water containing a few drops of commercial dishwashing liquid. GENTLY clean the bottom inch of the pH probe by rubbing with a cotton swab soaked in the cleaning solution. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water.

2. Soak the probe for approximately 1 hour in a 1 to 1 dilution of commercially available bleach. Rinse the probe with clean water and then soak for a minimum of 10 minutes in moving (e.g. stirred) clean water to remove residual bleach from the junction. Then re-rinse the probe with clean water.

   **<u>Caution:</u> Make sure bleach from previous step does not come into contact with HCl in following step. Toxic gases can be formed from reaction between chlorine and acid.**

3. Soak the probe for 60 minutes in one molar (0.3 to 1 M) hydrochloric acid (HCl). This reagent can be purchased from most laboratory supply dealers. Be sure to follow the safety instructions included with the acid and wear appropriate PPE. After soaking,

GENTLY clean the bottom 1 inch surface of the pH probe with a wet cotton swab. Rinse the probe in clean water, wipe again with a cotton swab saturated with clean water, and then re-rinse with clean water. To be certain that all traces of the acid are removed from the probe crevices, soak the probe in moving (e.g. stirred) clean water for a minimum of 10 minutes.

4. Dump out the probe's electrolyte solution and refill with fresh solution. Place probe in pH storage solution for 30 minutes and then recalibrate.

It will be necessary to replace the pH probe if the above cleaning steps restores proper performance.

## 4.6 Storage

### 4.6.1 LCA Storage

When not in use, the LCA should be cleaned according to recommendations using an approved cleaner, being sure to rinse sensors parts thoroughly with DI water afterwards. Store the sensor dry.

### 4.6.2 pH Probe Storage

Wipe off the pH probe with soft cloth or cotton swap and rinse with clean water. Place probe in storage bottle with pH electrode storage solution. Storage solution should be refreshed every 1 to 3 months depending on probe usage.

## 4.7 LCA Sensor Check and Calibration

### 4.7.1 Basic Function Test

The following procedure is a basic function test of the LCA Sensor:

- Press the Motor icon at the bottom of the screen to stop the motor if it is running.
- Remove the probe.
- Press the Motor icon to start the motor. Piston should be seen traveling up and down.
- Verify reading charge reading is 0 (+/-1)
- Press the Motor icon to stop the motor and reattach the probe.
- Place raw water (untreated) sample under the sensor.
- Reading should be -100 to -400.
- Dose sample with coagulant and verify reading can be titrated to zero (0). Note: If sample is low alkalinity water, it may require addition of lime or caustic if pH drops below 5 before the neutral endpoint is reached.

### 4.7.2 Test Procedure Using Verification Solutions

Chemtrac offers verification solutions to check the neutral endpoint accuracy of the LCA. These solutions are labeled "Verification Solution #1 – Anionic" and "Verification Solution #2 – Cationic". Both solutions are made down to the same charge strength such that one part of solution #1 is neutralized by 1 part of solution #2. The below procedure describes the verification procedure:

- Clean the probe and piston and sample beaker (a small 250 or 500 ml glass beaker can be used for this test) in accordance with section 4.2. Be sure to rinse parts thoroughly with DI water.
- Fill the sample beaker with DI water.
- Inject the sample with 10 ml of solution #1 (Anionic).
- Place sample under the LCA and allow reading to stabilize. Reading should be at least -100.
- Start titrating the sample with solution #2 (cationic). Start by injecting 9 ml of the solution. This will cause reading to go slightly less negative, but should not bring the reading to zero.
- Slowly add additional solution in 0.2 mL increments waiting several seconds between additions to see if the reading starts to change rapidly.
- Once the reading starts to change rapidly, wait to see if reading crosses over the neutral endpoint before adding any additional cationic solution.
- The neutral endpoint should be reached after adding 9.2 to 10.8 ml of solution #2.

If the titration results are not in the above range, it is suggested to clean the sensor again (but do not use any cleaners) and rinse the parts thoroughly with DI water and re-test. Contact factory for assistance if the LCA does not pass the verification test.

## 4.8 Application Questionnaire

The information requested below is important to qualifying the LCA for a given application. For each of the below items, please be sure to include the appropriate units of measurement that applies (e.g. MGD, m3/hr, ml/min, etc). Leave field blank if info is not known.

- Raw Alkalinity Typical:_____ Min:_____ Max:_____
- Raw pH Typical:_____ Min:_____ Max:_____
- Raw TDS/Conductivity Typical:_____ Min:_____ Max:_____
- Raw TOC (or UVA) Typical:_____ Min:_____ Max:_____
- Raw Turbidity (NTU) Typical:_____ Min:_____ Max:_____
- Post Coagulant pH Typical:_____ Min:_____ Max:_____
- Final TOC (or UVA) Typical:_____ Min:_____ Max:_____
- Is there more than one water source being treated? ____ No ____Yes (Please fill out above for each source)
- Operating Hours Per Day Typical:_____

**Very Important, Please Read Carefully**

The info requested below helps us to qualify the application, verify coagulant dosing calculation being used, and provide a testing procedure for the LCA. Please try to fill out every item. Basicity % only applies to "pre-hydrolyzed" forms of inorganic coagulant like ACH (Aluminum Chlorohydrate) or PACl (Poly Aluminum Chloride). Basicity information is typically not provided on the manufacturer's MSDS, so it may be necessary to contact your chemical supplier to obtain that info. Knowing basicity of the pre-hydrolyzed coagulants is very important to understanding how it will respond to charge measurement at any given pH.

**Primary Coagulant** (e.g. Alum, PACl):_____ Concentration:_____%

Weight/SG:_____ Basicity:_____% Does coagulant contain sulfate? _____ Yes _____ No

Coagulant Dose Typical:_____ Min:_____ Max:_____

***Provide the current readings for Dosage, Feed Rate, and RW Flow Rate (info used to verify dosage calculation).***

Dosage: _____ (mg/l or ppm) Feed Rate:_____ (circle one: ml/min, lbs/day, other_____)

Raw Water Flow Rate:_____ (circle one: MGD, GPM, Other _____)

(Below section is only applicable if using a secondary coagulant)

**Secondary Coagulant** (e.g. Alum, PACl):_____ Concentration:_____%

Weight/SG:_____ Basicity:_____% Does coagulant contain sulfate? _____ Yes _____ No

Secondary Coagulant Dose Typical:_____ Min:_____ Max:_____

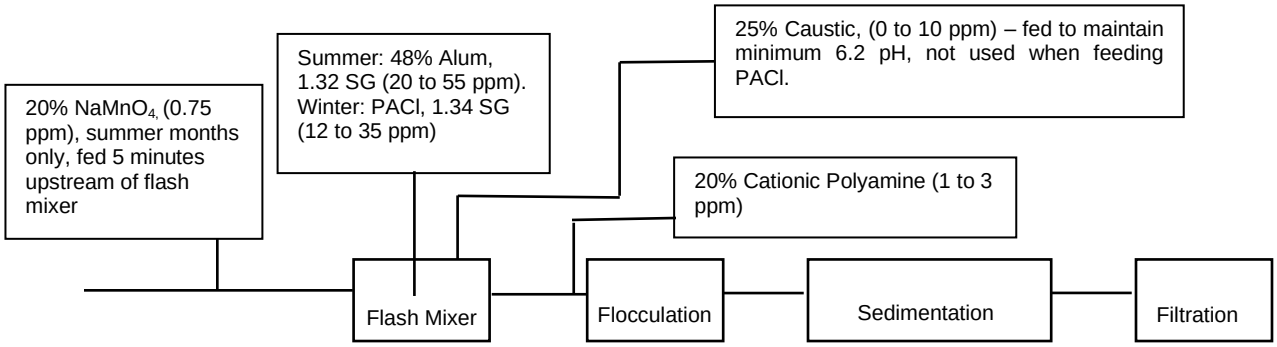
***Provide the current readings for Dosage, Feed Rate, and RW Flow Rate (info used to verify dosage calculation).***

Dosage: _____ (mg/l or ppm) Feed Rate:_____ (circle one: ml/min, lbs/day, other_____)

Raw Water Flow Rate:_____ (circle one: MGD, GPM, Other _____)

Provide a simple plant diagram showing basic description of the process and list all chemicals fed to process (prior to filtration) and their location. For each chemical please list the range of dosages typically used and other relevant information that is known about the chemical such as concentration (this info is used to help write SOP including making dilute solutions). Also include info on the lag time (contact time) between chemical addition points (this is especially important to know as it regards upstream disinfection). And detail any situations or times of year when any intermittently fed chemicals are typically used. Below is an example of the type of info requested:

***Example Diagram***




***Provide Your Diagram Below***

Contact Info:

Name_____ Title _____

Office Phone_____ Mobile_____

Email _____