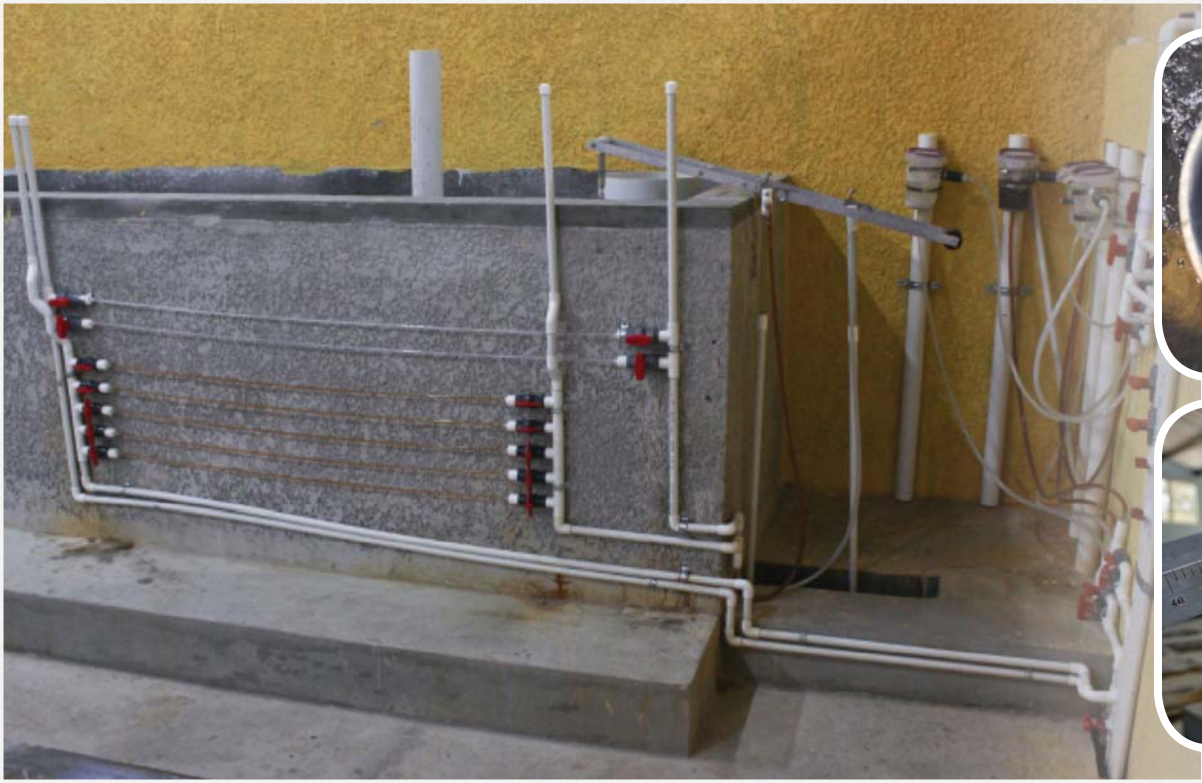
Chemical Dose Controller



The AguaClara Chemical Dose Controller (CDC) system is an innovative, completely hydraulic system that maintains a consistent dose of coagulant and disinfectant as the flow rate of the AguaClara plant fluctuates. The plant operator sets the appropriate chemical dosages directly without needing to calculate flow rates. The Linear Flow Orifice Meter (LFOM) creates a linear relationship between plant flow rate and the water depth in the entrance tank. When the plant flow rate changes, the water level in the entrance tank changes and the CDC float automatically adjusts the chemical flow rate to maintain a constant chemical dose.

The Chemical Dose Controller has been specifically designed with consideration of the communities in which they are being implemented:

Runs by gravity: no electricity required to maintain the desired chemical dosage

Minimizes moving parts and eliminates pumps

No proprietary components

Chemical hazards reduced by using liquid chlorine solutions rather than chlorine gas

Semi-automatic for ease of operation: calculations/testing needed only for verification and calibration

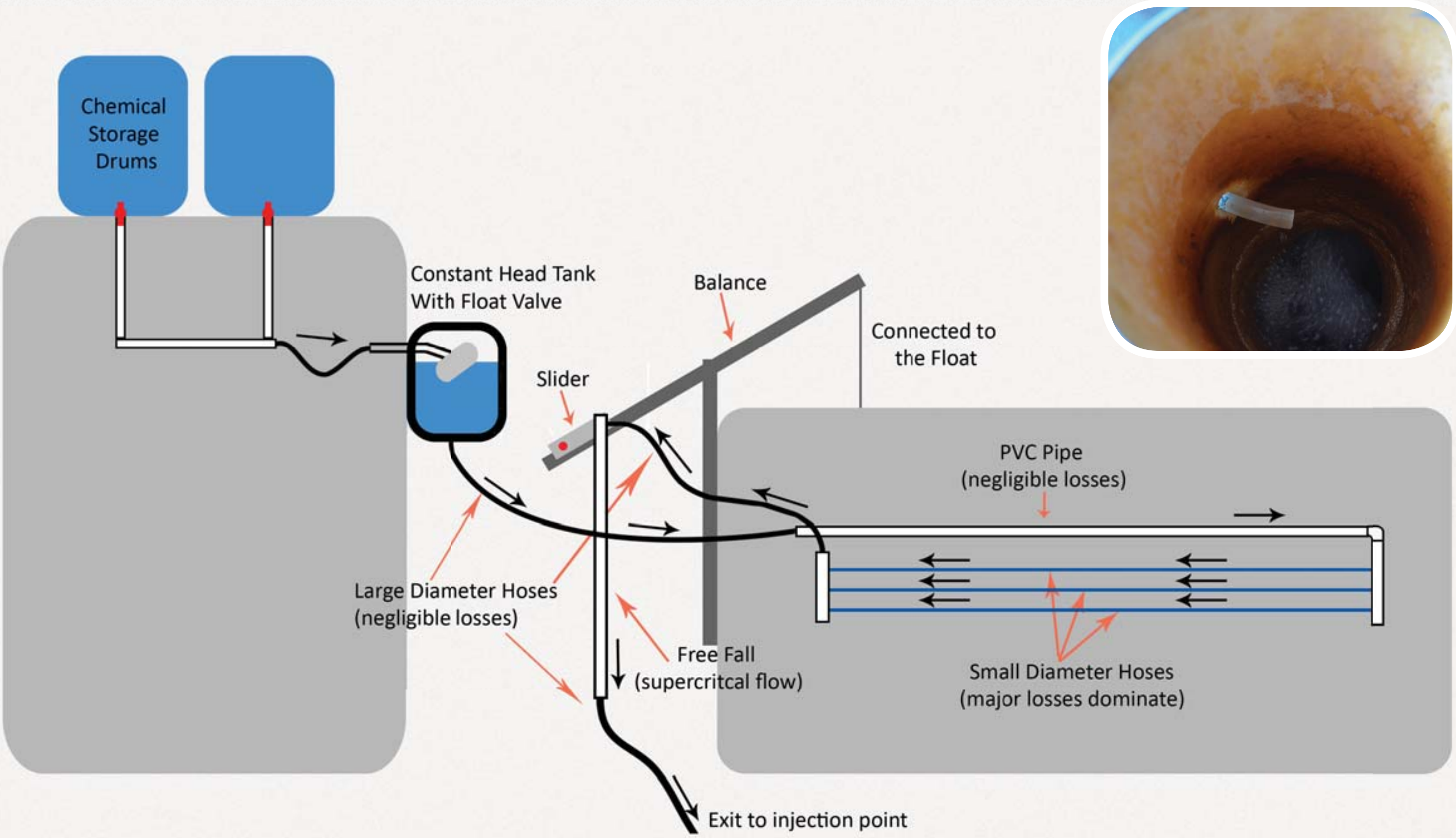

Note: a set of dosing tubes for each chemical

Benefits of the CDC

The CDC: Part By Part

The Major Components of the Chemical Dose Controller include:

- **Stock tanks** - 2 per chemical
- **Constant head tanks** - 2 per chemical (for redundancy)
- **Float**
- **Dosing tubes**
- **Lever arm** with dosing slide
- **Freefall dosing tube** and chemical injection point



The Linear Flow Orifice Meter (LFOM) ensures that the flow into the plant is linearized with respect to the height of the water in the entrance tank. The CDC creates a linearized dosing system to adapt accordingly to the varying water level in the entrance tank. In this way, the flow of water and the flow of chemicals is kept consistent automatically so the operator does not have to constantly monitor and change the dosing manually.

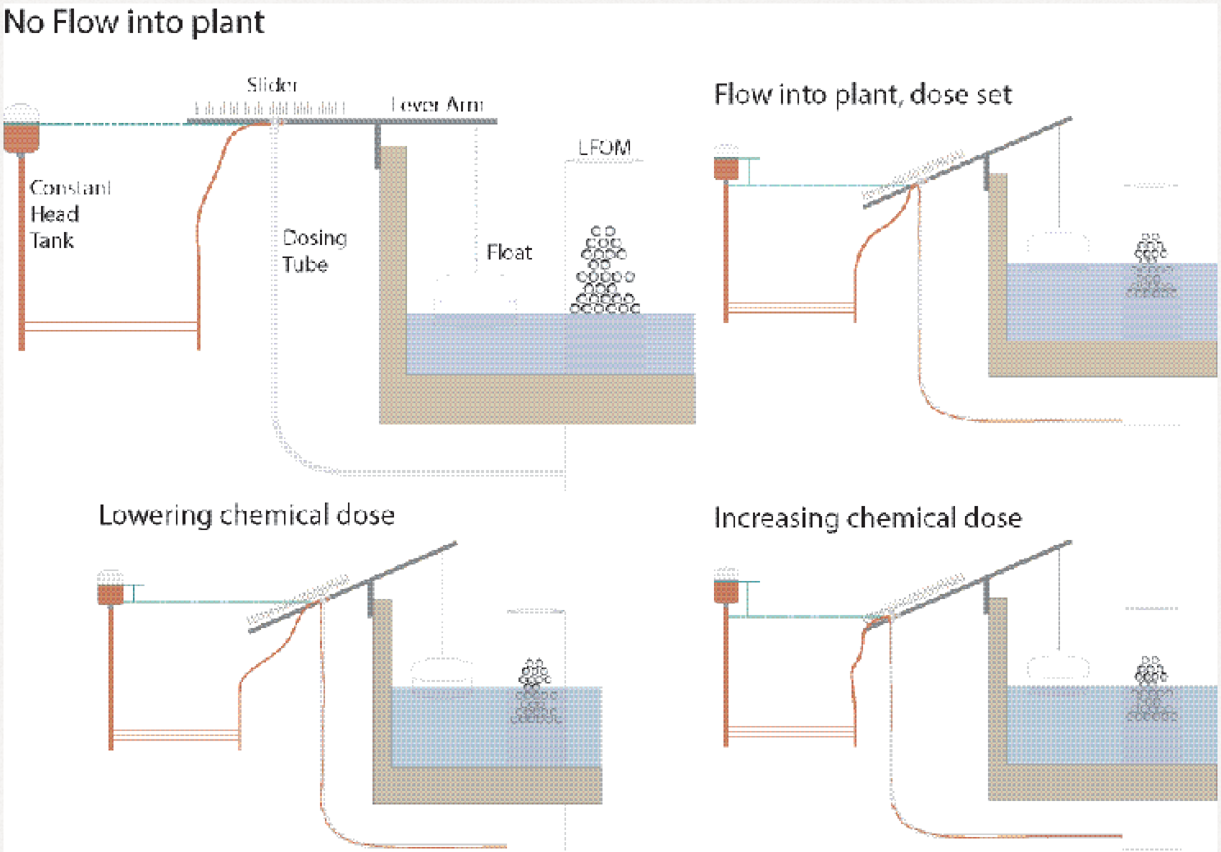
LFOM and Entrance Tank

Constant Head Tank and Lever Arm

A float valve in each constant head tank maintains a constant fluid level.

As the lever arm moves up or down, the drop tube (chemical injection point) also moves up or down. The chemical flow rate is proportional to the height difference (head) between the fluid level in the constant head tanks and the slider on the lever arm.

The two ways the elevation difference, which determines the chemical flow rate, can change are when: a plant flow rate change causes the entrance tank water level to change OR the operator changes slider position to adjust the dose.



To change the amount of chemical that is dosed, the slider is adjusted along the lever arm. There is a slider on the lever arm for each chemical being dosed, typically two.

The drop tube is attached to the slide on the lever arm, and is responsible for carrying the chemical to the injection point where it is mixed with the water flowing through the plant.

Headloss Relations Explained

The CDC couples a change in plant flow rate to a proportional change in chemical flow rate. A linear relationship between the driving head (entrance tank water level) and the chemical flow rate can be achieved by designing the minor head loss to be very small relative to major head loss in the dosing tubes.

$$h_l = h_e + h_f$$

This is the general head loss equation, including minor and major components.

$$h_e = \frac{8Q^2}{g\pi^2 D^4}\sum K_e$$

, where h_e is the minor head loss due to flow expansions associated with bends and plumbing connections, Q is the flow rate, D is the diameter of the pipe, and K_e are the coefficients of minor losses.

$$h_f = \frac{128 \nu Q L}{g\pi^2 D^4}$$

, where h_f is the major head loss due to wall friction, ν is the kinematic viscosity of the fluid (water), and L is the length of the pipe.

Dosing Tubes Details

The dosing tubes are long, straight tubes with a small diameter. They are designed to be linear head loss elements. The small diameter and straight line of the tubes makes the major head loss dominate. All connections and flow transitions are designed to have a larger inner diameter than the dosing tubes to minimize minor head loss.

Each dosing tube has a maximum allowable flow that meets the minor loss constraint. Multiple dosing tubes can be arranged in parallel if higher chemical flow rates are required. At least one extra dosing tube is always included so that a dosing tube can be taken off line to be cleaned or replaced.

Variable Head Loss Capacity

The CDC and LFOM can be designed to work with a range of head loss. Plants with flow rates between 4 L/s and 60 L/s are currently using LFOMs with 20 cm of water level change. Chlorine doser systems have been installed that use 10 cm of water level change. It may be attractive to use higher LFOM head loss for higher plant flow rates to decrease the required LFOM diameter.

Dosing Tubes and Major/Minor Losses

Frequently Asked Questions

How does the operator select the coagulant dose?

The CDC allows plant operators to quickly set a desired coagulant dose. The plant operators monitor raw water turbidity, settled water turbidity, the size of flocs, and clarity of water between the flocs in the flocculator. Small flocs, cloudiness between flocs, increasing raw water turbidity, or increasing settled water turbidity suggest that the coagulant dose must be increased. Although the relationship between coagulant dose and raw water turbidity is different for each water source and water treatment plant, the plant operators are able to develop an operating guide for chemical dosing at their plant. **Jar tests** are a simple simulation of the flocculation/ sedimentation process that are sometimes used to compare several coagulant dosages.

How does the operator select the chlorine dose?

Unlike the coagulant, the chlorine does not provide visible feedback inside the plant which can confirm that the dose is adequate for complete disinfection. Laboratory chlorine demand test with filtered water can provide a starting point for selecting the required dose. The most effective method for ensuring complete disinfection and protection in the distribution system is to test the **free chlorine residual** frequently at various points in the distribution system. The chlorine dose at the plant can be adjusted if the residual is not detected or is insufficient. A dose that maintains a free chlorine residual to meet water quality regulations should be used.

What constraints exist on the design of the dosing tubes?

Diameter: Head loss is very sensitive to changes in tube diameter. Chemical dosing for a wide range of plant flow rates can be provided using 1 to 4 3.2 mm diameter dosing tubes installed in parallel. Lower flow rates may benefit from using 1.6 mm dosing tubes. Lower chemical flow rates can also be achieved by using longer dosing tubes.
Length: Vary length to obtain desired maximum chemical flow rate at the maximum CDC head loss.
Orientation: Keep tubes straight to minimize minor losses due to curvature. Tubes can be oriented either horizontally or vertically depending on the space available for installation.

What type of maintenance is required for the AguaClara chemical dose controller?

Both the coagulant and chlorine systems accumulate solids in the stock tanks, plumbing, constant head tanks, and dosing tubes. Both systems should be cleaned regularly to maintain the constant flow of each chemical according to the dose set on the lever arm. The coagulant sediment is normally trapped in the constant head tank and can be easily emptied If calcium hypochlorite granules are use to prepare the chlorine stock solution, then calcium carbonate scaling will form in the chlorine CDC. The calcium carbonate scaling can be more easily dissolved with a weak acid such as vinager.

Why are there redundant components?

The dose controllers are installed with two stock tanks, two constant head tanks, and an extra dosing tube for each of the chemicals. This allows the operator to refill, clean, or perform maintenance on any of these components without interrupting the flow of chemical. He or she simply switches to the alternative tank or tube to perform maintenance.. It is crucial that the flow of coagulant never be interrupted during operation, since the flocculation fails without coagulant. Likewise, interruption of the chlorine dose could allow water with inadequate disinfection to enter the distribution system.

Can the linear chemical dose controller be adapted for use apart from an AguaClara plant?

Yes. The set-up can be adapted for independent chlorine feeds, coagulant dosing in non-AguaClara plants, or any other purpose that requires precise chemical feed of a liquid chemical that maintains the target chemical dose during changes in plant flow rate.

The primary installation necessary to use the linear chemical dose controller is an entrance box with a linear flow meter where a float can link the dose controller with the incoming flow rate. This box can also be a place to observe the raw water, control the flow rate, or settle grit as needed, as it is in the AguaClara plants. The doser will also need an elevated platform for the chemical stock solutions and a structure on which to mount the constant head tanks, calibration columns, and dosing tubes.

How does the operator know if the CDC is performing correctly?

The operator can observe the stream of chemical in the transparent drop tube to visually confirm that the chemicals are flowing. The fluid level in the constant head tanks can also be readily observed. Plant operators measure the flow rate using the calibration column on a regular basis (frequency depending on local regulations) to verify that that the flow rate is within specifications.

How long do the chemical stock solutions last?

While the concentrated coagulant stock is stable and can be stored for months, the calcium hypochlorite stock will decay slowly depending on its temperature and concentration. The chlorine dose controllers are, therefore, designed to deplete the stock solution in one week or less to minimize the effect of decreasing chlorine concentration.