



CLmaster™ White Paper

Closed-loop machine-learning control of chlorine and chloramine disinfection

Summary

Chlorine disinfection at water resource recovery facilities is usually controlled with fixed dosing tables, fixed chlorine-to-ammonia ratios or PID loops, and operators dose conservatively to be sure of meeting the disinfection target. CLmaster replaces this with closed-loop, real-time control that adjusts sodium hypochlorite and aqueous ammonia doses continuously to hold the target CT, the product of total chlorine residual and modal contact time.

1. The disinfection target

Disinfection performance is commonly specified as CT. In California, Title 22 sets a CT of 450 mg·min/L for disinfected tertiary recycled water, together with a minimum modal contact time of 90 minutes at peak dry weather flow and continuous monitoring of the disinfectant residual. The CT standard was informed in part by the Pomona Virus Study carried out at the same plant in the late 1970s.

2. Why conventional dosing falls short

- **Fixed rules in a changing process.** Dosing tables, fixed ratios and PID loops do not follow real-time changes in flow, chlorine decay, and ammonia or organic load.
- **Conservative dosing.** To be sure of compliance, operators dose above what the target requires. This raises chemical costs and increases the formation of disinfection byproducts.
- **Process delays.** Chemical added now reaches the measurement point minutes later, after transport through pipes and filters. Control that reacts only to the present reading tends to overcorrect.
- **Manual flow adjustment.** Where influent flow is set by manual gate adjustments, step changes in flow propagate to every downstream process, including disinfection.

3. The CLmaster approach

- **CT as the control target.** The doses are adjusted to hold CT at the target as flow and contact time change.
- **Coordinated dosing.** Sodium hypochlorite and aqueous ammonia are controlled together, so

that the chlorine-to-ammonia ratio stays in the range that forms monochloramine and avoids dichloramine and trichloramine.

- **Use of process history.** The control uses the recent history of doses and residuals, so it accounts for chemical already in transit and anticipates changes instead of reacting late.
- **Machine learning where the process is non-linear.** Models trained on the plant's own data are used where fixed formulas cannot describe the process accurately.
- **Safe limits.** Dose limits and limits on the rate of change keep every adjustment within safe bounds.
- **Data validation.** Every reading is checked before it is used. Faulty readings are detected and not acted on, and operators are alerted.
- **Standard communication.** CLmaster exchanges data with the plant SCADA system using the standard OPC protocol.

4. Building on stable ammonia

At Pomona, machine-learning ammonia-based aeration control, implemented in Water Research Foundation Project 5148, made the effluent ammonia more stable and allowed aqueous ammonia addition for chloramination to be reduced or eliminated. Stable ammonia from the biological process makes precise control of the disinfection chemicals possible. CLmaster and DO/Nmaster are designed to work together.

5. Operator authority

CLmaster acts automatically, but operators keep authority. They can override the system at any time, and if sensors fail, control returns to the operators.

6. Instruments

CLmaster uses chlorine and ammonia analyzers, flow measurement and the existing chemical feed pumps. These can be bought from any supplier. Ekster & Associates sells no hardware, but provides recommended performance specifications.

7. Next step

A free plant assessment estimates the benefits for a specific plant. Send one year of operating data and chemical purchase records. You will receive a written estimate of savings in chemical use and dollars, the assumptions behind it, any changes required before installation, and a fixed price. If your plant is already operating efficiently, the estimate will say so.

References

1. Water Research Foundation Project 5148 (completed): machine-learning ammonia-based aeration control for low dissolved oxygen operation at the Pomona Water Reclamation Plant.
2. Ekster & Associates (2025). Automated Chloramination Control System for Enhanced Disinfection Performance (system description).

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