DO/Nmaster™ — Frequently Asked Questions

What is DO/Nmaster?

DO/Nmaster is a machine-learning based real-time control system for airflow, dissolved oxygen (DO) and ammonia in activated sludge aeration systems. It replaces the conventional PID control loops with control that learns from the plant's own operating data. For each aeration grid it calculates setpoints for airflow, DO and valve position, and sends them to the plant's SCADA system. When ammonia-based aeration control is used, ammonia becomes the master control parameter and the DO setpoints are calculated from it.

Why does precise control matter, especially at low dissolved oxygen?

When DO is held above the level the process needs, energy is wasted and nitrogen removal can deteriorate. When it falls too low, nitrification and sludge settling suffer. Below 1 mg/L the margin is small: at the Pomona Water Reclamation Plant, reducing the average DO by only 0.03 mg/L doubled the effluent ammonia concentration. Plants that run at low DO therefore need control that holds setpoints closely.

Why does conventional PID control fall short?

PID control applies a fixed linear formula. Aeration systems are not linear: with butterfly valves, a change of two to three degrees in opening can double the airflow. Each valve and blower loop usually operates independently, and the loops interfere with one another, which causes valve and blower hunting. At Pomona, under the same conditions, the average DO control error was 0.20 mg/L (20%) with tuned PID control and 0.06 mg/L (6%) with DO/Nmaster.

How accurate is the airflow control?

At Pomona, the average airflow control error was 0.75% and the median error 0.25%, using butterfly valves with precise modulating actuators and fast airflow meters. This is comparable to control with linear-characteristic valves. At the City of Chico, machine-learning valve models have been used in the airflow control loops since 2019 with a median error of 2.9%.

Does DO/Nmaster require new blowers or other hardware?

It requires no new blowers. DO/Nmaster runs on a Windows-based computer and communicates with the existing SCADA system using the standard OPC protocol; the existing PLCs or DCS continue to operate the valves and blowers. Accurate control does depend on suitable instruments: fast airflow meters, modulating actuators designed for process control, and DO and ammonia analyzers. These can be bought from any supplier. Ekster & Associates sells none of them, but provides recommended performance specifications.

Can operators override the system?

Yes. Operators can override DO/Nmaster at any time, and they set the setpoints and control limits through the operator interface.

What happens if a sensor or actuator fails?

Every reading is checked before it is used. Faulty readings are detected and not acted on, and operators are alerted. Abnormal actuator behavior is also detected and reported.

What energy savings have been achieved?

At the City of Chico, a 2018 control project built around DO/Nmaster (DO/Nmaster; 15 automated valves; 15 airflow meters; 3 ammonia meters; DO meters increased from 6 to 15; centrate storage with night-time injection; improved blower sequencing), with the existing blowers and diffusers, reduced aeration energy per pound of oxygen demand by 47.6%, saving 1,198,692 kWh per year, as verified under PG&E's California Wastewater Process Optimization Program. At Pomona, aeration energy fell from 1,300 to 550 kWh per million gallons of influent (kWh/MG): replacing 50-year-old centrifugal blowers with high-efficiency blowers reduced blower energy by 34%, and lowering the DO setpoints with DO/Nmaster and SRTmaster added a further 30% (U.S. Department of Energy final report).

Does lower DO reduce nitrogen removal?

Not at Pomona. Total inorganic nitrogen removal averaged about 84% both before and after the transition to low DO. Ammonia was controlled precisely enough to reduce or eliminate the aqueous ammonia added for chloramination.

How reliable is it?

DO/Nmaster has been in service at the City of Chico since 2018, and at the Pomona Water Reclamation Plant of the Los Angeles County Sanitation Districts since the U.S. Department of Energy demonstration.

How does DO/Nmaster work with SRTmaster?

The two systems share the same architecture. SRTmaster holds the sludge age (solids retention time) close to its target, which keeps the biomass stable as DO is lowered. At Pomona, the average SRT control error was 0.13 days, less than 2%.

How is the saving for my plant estimated?

A free plant assessment estimates it. Send one year of operating data and energy bills. You will receive a written estimate of savings in kWh 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.

Sources

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- QuEST (2018). *California Wastewater Process Optimization Program, Post-Installation Verification Report, City of Chico WWTF.* PG&E / CPUC.
- Ekster, A., Alchakov, V., Meleshin, I. and Larionenko, A. (2021). Modeling Performance of Butterfly Valves Using Machine Learning Methods. *Sustainability* 13, 13545.
- Larionenko, A., Alchakov, V. and Ekster, A. (2020). Case Study: Using machine learning tools for accurate flow control. *Flow Control*, November 2020.
- Ekster & Associates (2025). DO/Nmaster and SRTmaster at the Pomona WRP, project summary.

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