WHITE PAPER · CHLORAMINATION

Monochloramine measurement, without reagents.

A continuous, reagent-free approach to measuring free chlorine and monochloramine on the same sensor — and the new control strategy it enables for chloraminating plants.

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PRODUCT

Halogen MP Total
(model MP6)

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EXECUTIVE SUMMARY

One sensor. Both species. No reagents.

> For chloraminating drinking-water utilities, accurate continuous measurement of monochloramine has historically forced an unacceptable trade-off: either fly the breakpoint curve blind using DPD Total measurements that cannot distinguish between chlorine species, or install reagent-based online analyzers that cost thirty thousand dollars, consume thousands of dollars of reagent per year, and produce tens of thousands of gallons of waste stream. The Halogen MP Total removes the trade-off.

Free + Mono

Continuous, independent measurement of free chlorine and monochloramine on a single sensor

Zero reagents

No reagent consumption, no reagent handling, no waste stream

2-minute updates

Measurement refresh every 2 minutes, vs 4.5–20 minutes for reagent analyzers

6+ months

Calibration intervals, inherited from the proven MP5 self-cleaning platform

What this paper covers

This white paper explains why conventional measurement methods — DPD Total, DPD Free, and amperometric membrane sensors — cannot provide the species-specific visibility chloramination operators need; documents the operational consequences of that blindness, including chronic over-dosing and nitrification risk; and describes a new approach to continuous chloramination control that the MP Total enables for the first time, based on maintaining a small free chlorine residual at the top of the breakpoint curve rather than carrying excess free ammonia.

“You had me at mono and free on the same sensor.”

Chloramination plant operator, March 2026

BACKGROUND

Why chloraminate — and why measurement is hard.

Why monochloramine

Monochloramine is used as a secondary disinfectant in drinking water treatment for three reasons. It is more stable than free chlorine and remains effective across the extended residence times of a distribution network. It produces fewer disinfection by-products (DBPs) than chlorine, which helps utilities meet increasingly tight regulatory limits on trihalomethanes and haloacetic acids. And it produces less of the taste and odor profile that draws customer complaints about chlorinated water. Most utilities that switch to chloramination do so for some combination of these three reasons, often with DBP compliance as the direct trigger.

The chemistry is narrow

Monochloramine (NH_2Cl) forms when free chlorine and ammonia are combined at a specific weight ratio — typically between 4.5:1 and 5:1 chlorine to ammonia. Ratios above this range begin producing dichloramine ($NHCl_2$), which causes the characteristic "swimming pool" taste and odor complaints, and at still higher ratios, trichloramine (NCl_3). Ratios below this range leave excess free ammonia in the treated water, which drives nitrification in the distribution network.

The formation ratios are themselves pH-dependent. At pH 6.5–8.5 (typical drinking water range), monochloramine is the dominant species. Below pH 7, dichloramine and trichloramine formation becomes favored. Above pH 8, the chemistry strongly favors monochloramine. Operators who chloraminate consequently target pH conditions above 8 and manage chlorine-to-ammonia ratios tightly around the optimum.

Narrow chemistry requires visibility

Because the chloramine chemistry window is narrow and the consequences of drifting out of it are costly — taste complaints, nitrification events, coliform violations, customer anger — accurate and continuous measurement of the actual species distribution in the treated water is essential. This is precisely where conventional measurement methods fail.

THE CORE PROBLEM

One total chlorine reading. Four very different plants.

The most widely deployed continuous measurement method for chloraminated water is the DPD Total chlorine sensor. A DPD Total reading returns a single number: the combined concentration of all oxidizing chlorine species in the sample. It tells the operator *how much total chlorine is in the water.* It does not tell the operator *which species* that total chlorine consists of.

This distinction is not a theoretical curiosity. It is the difference between a plant running optimally and a plant about to generate nitrification complaints, taste complaints, or regulatory issues.

SCENARIO	TOTAL	FREE CL	MONO	DI	TRI
Optimal chloramination	**3.0**	**0**	**3.0**	**0**	**0**
Incomplete reaction (excess free Cl)	**3.0**	**1.0**	**2.0**	**0**	**0**
Dichloramine forming (taste complaints)	**3.0**	**0**	**2.0**	**1.0**	**0**
Trichloramine forming (low pH drift)	**3.0**	**0**	**2.0**	**0**	**1.0**

All values in mg/L. The total chlorine reading is identical in every row.

Every row above would produce an identical reading on a DPD Total sensor. The first is the condition every chloraminating utility is trying to hit. The last two would already be producing customer complaints by the time the operator noticed. The middle is the setup for a nitrification event. The measurement system cannot distinguish between them.

DPD Free is no better

The obvious instinct — measure DPD Free and subtract from DPD Total to infer monochloramine — also fails. Monochloramine is a well-known interferent in DPD Free measurements. In practice, a DPD Free sensor operating in chloraminated water reads a blend of free chlorine and a fraction of the monochloramine residual, and the size of that fraction depends on sample chemistry, contact time, and temperature. Subtracting one unreliable number from another unreliable number does not produce a reliable answer.

The same fundamental interference applies to amperometric membrane chlorine sensors. These sensors measure oxidizing species across a membrane and cannot intrinsically distinguish free chlorine from monochloramine in the same sample stream. Every conventional continuous-measurement method available to a chloraminating plant carries some version of the same species-ambiguity problem.

OPERATIONAL CONSEQUENCES

The nitrification cascade.

The inability to measure free chlorine and monochloramine independently forces chloraminating plants into a defensive control strategy. Because the operator cannot directly verify that the chlorine-to-ammonia ratio is correct in the treated water, the standard practice has been to carry a small excess of free ammonia at the point of chloramine formation — on the principle that excess ammonia is safer than excess free chlorine, because excess free chlorine can react with the ammonia to form dichloramine.

This defensive strategy has a second-order consequence that utilities have been managing for decades: the excess ammonia that leaves the treatment plant is the feedstock for nitrification in the distribution network.

THE CASCADE

Excess ammonia in treated water → ammonia-oxidizing bacteria convert it to nitrite → nitrite consumes chloramine residual at roughly 5:1 (2 mg/L chloramine lost per 0.4 mg/L nitrite produced) → chloramine residual falls → bacteria grow → biofilm forms → pH drops → lead and copper corrosion accelerate → heterotrophic plate counts rise → coliform violations become possible.

Utilities manage nitrification events through distribution-system flushing, temporary "free chlorine burns" to disinfect the network, and seasonal operational adjustments. These interventions are expensive, labor-intensive, and reactive — they address the symptom after the nitrification event has begun, not the root cause. The root cause is that the plant cannot see its free-chlorine-to-ammonia ratio with enough precision to avoid carrying excess ammonia in the first place.

The measurement gap drives the operational compromise

If a plant could continuously measure free chlorine and monochloramine independently, at the same sample point, at a refresh rate faster than the process dynamics, the operator could dose to a chlorine-forward condition — a small positive free chlorine residual with zero free ammonia — and take nitrification off the risk register entirely. Doing this with conventional instrumentation is not possible.

CURRENT SOLUTIONS

The price of seeing both species.

A small number of online analyzers do address the species-visibility problem by using reagent chemistry — most commonly an indophenol or similar colorimetric method — to react with monochloramine specifically and produce a species-selective signal. These analyzers work. They are also operationally expensive in ways that put them out of reach for most small and mid-sized utilities.

Equipment cost

METHOD	EQUIPMENT COST
Monochloramine & ammonia reagent-feed analyzers	$29,000 – $33,000
Free and Total reagent systems	~$15,000
Halogen MP Total (free Cl, monochloramine, pH, conductivity)	**$10,700**

Consumable and operating cost

METHOD	REAGENTS/ YR	WEAR PARTS/ YR	WASTE STREAM
Monochloramine & ammonia reagent-feed	$3,000	$1,000	70,000–150,000 gal/ yr
Free and Total reagent systems	$1,400	$300	140,000 gal/yr
Halogen MP Total	**$0**	**$590**	**0 gallons**

Measurement refresh rate

METHOD	TIME BETWEEN MEASUREMENTS
Monochloramine & ammonia reagent-feed	4.5 – 20 minutes
Free and Total reagent systems	< 1 minute
Halogen MP Total	**< 2 minutes**

The capital delta between a reagent-based monochloramine analyzer and the MP Total is meaningful, but the recurring operating cost delta — reagent consumption and the associated waste stream — is the cost that accumulates year after year and drives the business case for most utilities. Avoiding $4,000 of annual reagent consumption and 70,000–150,000 gallons of annual waste water, per analyzer, is the larger structural saving.

THE MP TOTAL

Reagent-free measurement of both species, on a proven platform.

The Halogen MP Total is an amperometric sensor platform designed specifically to measure free chlorine and monochloramine independently, without reagents, without a membrane, and without a sample waste stream. Its hardware is directly derived from the MP5 chlorine sensor platform, which is currently in service in drinking water, industrial, and leisure applications including a multi-month independent evaluation at Wessex Water's Compton Durville treatment works where it operated for five months with no calibration, cleaning, or maintenance intervention.

What's in the sensor

The MP Total inherits the core architectural elements of the MP5:

- An internal pump driving sample flow across the electrode surfaces at a controlled, high velocity — making the sensor flow-independent with respect to the surrounding sample stream and maximizing signal-to-noise at the electrode.
- A captive bead cleaning system that continuously scours the electrode surfaces during operation, preventing fouling accumulation that would otherwise degrade accuracy between service visits.
- Magnetic coupling between the impeller and the motor, eliminating shaft seals and the wear and failure modes they introduce.
- Bare electrodes — no membrane between the sample and the sensing surface, eliminating the 24-hour calibration wait that membrane sensors require.

What distinguishes the MP Total from the MP5 is the electrode chemistry and the signal-processing approach that enable independent, continuous discrimination between free chlorine and monochloramine in the same sample stream. Multiple patents have been filed covering the measurement method.

Installed parameters

The MP Total is typically deployed with an accompanying multiparameter display (the Halogen D20 controller) and reports the following parameters from a single in-pipe installation:

- **Free chlorine** — independently measured, not inferred from total − monochloramine subtraction
- **Monochloramine** — measured directly, without reagent chemistry
- **ORP** (oxidation-reduction potential)
- **pH**
- **Conductivity**
- **Temperature**

The sensor is NSF 61 certified for contact with drinking water and installs directly into a live pipe via a wet-tap assembly, with no need for a separate sample panel or constant-flow cell.

A NEW CONTROL METHOD

Run chlorine-forward, not ammonia-forward.

Continuous visibility of free chlorine and monochloramine on the same sample stream enables a control strategy that has not been practical with previous instrumentation: maintain a small positive free chlorine residual, and zero free ammonia, at the exit of the chloramination process.

The traditional strategy, and its cost

The conventional operating approach is *ammonia-forward*: carry a small excess of free ammonia to guarantee that no free chlorine is left in the water that could react downstream to form dichloramine. This strategy is driven by what the operator *can* see — DPD Total — and what the operator *cannot* see, which is whether the species ratio in the water is correct. Excess ammonia is the hedge against an unseen ratio error, and it is also the feedstock for every nitrification problem that follows.

The new strategy

With continuous, reagent-free measurement of free chlorine available, the operator can run *chlorine-forward* instead. The target becomes a small positive free chlorine residual — typically 0.04 to 0.08 ppm — with all monochloramine formation driven to completion and no free ammonia exiting the process. At pH above 8.5, the small free chlorine residual does not form dichloramine because dichloramine formation is not thermodynamically favored at that pH. The plant operates at the top of the breakpoint curve, optimized for disinfection, with minimal excess ammonia in the network.

TRADITIONAL: AMMONIA-FORWARD

Target: Small excess free ammonia at plant exit.

Reasoning: Operator cannot see free chlorine reliably in the presence of monochloramine; hedges with excess ammonia.

Side effect: Excess ammonia drives nitrification downstream. Requires reactive distribution-system management (flushing, free chlorine burns).

MP TOTAL: CHLORINE-FORWARD

Target: 0.04–0.08 ppm free chlorine, zero free ammonia at plant exit.

Reasoning: Continuous, independent measurement of free chlorine and monochloramine confirms the species ratio is correct in real time.

Side effect: No excess ammonia enters the network. Nitrification risk removed at the source.

This control approach is enabled by the MP Total's 2-minute measurement refresh — fast enough to support closed-loop control of the chlorine:ammonia feed — and by the sensor's ability to measure both species independently without interference. No other sensor architecture available to chloraminating utilities supports the strategy described above.

CONCLUSION

A reagent-free path out of the species-ambiguity problem.

Summary of findings

- Continuous chlorine species measurement has historically forced chloraminating utilities to choose between DPD Total methods that cannot distinguish species and reagent-based online analyzers that cost $30,000+ in capital and $4,000/year in consumables while producing 70,000+ gallons of waste stream annually.
- The species-ambiguity problem drives a defensive control strategy — ammonia-forward operation with a small excess of free ammonia — that is the root cause of nitrification risk in chloraminated distribution networks.
- The Halogen MP Total provides continuous, reagent-free, species-selective measurement of free chlorine and monochloramine from a single sensor installation, at a capital cost roughly one-third that of reagent-based alternatives and with zero consumable reagent consumption and zero waste stream.
- The measurement capability enables a chlorine-forward control strategy — a small positive free chlorine residual with zero free ammonia at plant exit — that removes nitrification risk at the source rather than managing it reactively in the distribution network.

What this means for operators

Chloraminating utilities evaluating instrumentation replacement should consider the MP Total against both existing DPD Total methods (which the MP Total replaces with higher measurement fidelity) and against reagent-based monochloramine analyzers (which the MP Total replaces at significantly lower capital and operating cost). Utilities implementing or considering a chlorine-forward control strategy should note that the MP Total is, as of the date of this paper, the only sensor architecture commercially available that can support it.

See how the MP Total performs on your site.

Request a demo, discuss a pilot installation, or ask any question this white paper didn't answer.

halogensystems.com

ABOUT THE AUTHOR

Michael Silveri is the founder of Halogen Systems, Inc., and the architect of the MP5 and MP Total sensor platforms. The company holds multiple filed patents covering the reagent-free measurement methods described in this paper. Production and field deployment of the MP Total is supported by Halogen Systems' engineering and field services teams in the US, UK, and European Union.