



Legionella risk reduction through continuous chlorine monitoring.

W H I T E P A P E R · L E G I O N E L L A P R E V E N T I O N

How reagent-free amperometric sensors deliver the continuous residual monitoring needed to keep building water systems safe from Legionella pneumophila — and why traditional grab-sample programs fall short.

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EXECUTIVE SUMMARY

Continuous monitoring. Continuous protection.

Legionella pneumophila thrives when disinfectant residuals drop — even briefly — in building water systems. Traditional grab-sample testing catches snapshots, not the gaps between them. Continuous, reagent-free chlorine monitoring closes those gaps, providing real-time visibility into residual levels and enabling immediate corrective action before conditions become dangerous.

10,000+

Estimated Legionnaires' disease cases annually in the U.S., with a case-fatality rate of roughly 10%

0.2 ppm

Minimum free chlorine residual at distal points recommended by ASHRAE 188 to suppress *Legionella* growth

Zero reagents

No chemical consumables, no waste stream, no ongoing reagent cost — continuous measurement 24/7

2-min updates

Fresh chlorine measurement every two minutes vs. weekly or monthly grab samples at best

BACKGROUND

Legionella: a persistent threat in building water

Legionnaires' disease is a severe, often fatal form of pneumonia caused by inhaling aerosolized water contaminated with *Legionella pneumophila*. The bacterium colonizes building water systems — hot water tanks, cooling towers, decorative fountains, and complex plumbing networks — wherever water temperatures favor growth (77–113°F) and disinfectant residuals are inadequate.

According to the CDC, reported cases of Legionnaires' disease in the United States have increased more than nine-fold since 2000. Healthcare facilities, hotels, and large commercial buildings are particularly vulnerable because their plumbing systems create the stagnation, warm temperatures, and biofilm conditions that Legionella exploits. Outbreaks carry devastating consequences: patient illness and death, regulatory shutdown, litigation, and reputational damage.

The primary defense is maintaining adequate disinfectant residual throughout the water distribution system. Free chlorine (or monochloramine, in chloraminated systems) must remain at sufficient levels at every point — especially at distal outlets farthest from the treatment point. When residuals drop below protective thresholds, Legionella can proliferate rapidly.

Grab samples miss the gaps that matter

Most building water management programs rely on periodic grab sampling — collecting a water sample at a tap, testing it with a colorimetric method (typically DPD), and recording the result. This approach has fundamental limitations:

Temporal blindness

A grab sample represents a single moment. If residuals drop to zero overnight due to water age, stagnation, or demand patterns, the weekly Tuesday-morning sample will never detect it. Legionella needs only a brief window of low residual to establish and grow.

Labor intensity and cost

Comprehensive grab-sample programs at large facilities can require dozens of sample points, each needing a trained technician to collect and test. The labor burden limits how many points can be tested and how often. Facilities typically test weekly or monthly — intervals that leave long periods of unmonitored risk.

Operator variability

DPD colorimetric tests are subject to significant operator variability. Sample handling, reagent freshness, color interpretation, and timing all affect accuracy. Studies have shown DPD results can vary by ± 0.2 ppm or more between operators — a range that spans the difference between safe and unsafe conditions at the lower end of the residual scale.

THE GAP PROBLEM

A building water system with weekly grab samples is monitored for roughly 0.001% of the week. The other 99.999% is invisible. Legionella doesn't wait for sample day.

MONITORING APPROACH	SAMPLE FREQUENCY	COVERAGE	REAGENT COST/YEAR
Weekly grab sample (DPD)	1 × per week per point	~0.001%	\$200–500/point
Daily grab sample (DPD)	1 × per day per point	~0.007%	\$1,000–2,500/point
Reagent-based online analyzer	Every 2.5–15 min	~90%	\$2,000–5,000/unit
Halogen MP5 (amperometric)	Every 2 min, continuous	~100%	\$0

Continuous, reagent-free chlorine monitoring

The Halogen MP5 is a reagent-free amperometric chlorine sensor designed for continuous, unattended operation. Unlike colorimetric analyzers that consume chemical reagents to produce each measurement, the MP5 uses a bare-electrode amperometric cell that measures chlorine directly through an electrochemical reaction — no reagents, no membranes, no waste.

Key capabilities for Legionella prevention

Continuous 2-minute measurement cycle. The MP5 delivers a fresh chlorine reading every two minutes, 24 hours a day. This eliminates the temporal blind spots inherent in grab-sample programs. If residuals drop — even at 3 AM on a Sunday — the system detects it immediately.

Zero reagent cost and zero waste. The amperometric measurement principle requires no chemical consumables. There are no reagent cartridges to replace, no reagent waste to dispose of, and no risk of running out of reagent between service visits. This makes the MP5 practical for deployment at multiple monitoring points throughout a building — something that would be prohibitively expensive with reagent-based analyzers.

Self-cleaning sensor. The MP5 incorporates an automatic self-cleaning cycle that prevents fouling and biofilm accumulation on the sensor surface. This is critical in building water applications where biofilm growth is both a measurement interference and a Legionella risk factor.

Low-flow and low-pressure operation. Building water monitoring points often have low flow rates and inconsistent pressure. The MP5 is designed to operate accurately under these conditions without requiring sample conditioning, pressure regulation, or minimum flow rates — unlike many online analyzers that need regulated, pressurized sample streams.

Automated alerting. When connected to a building management system (BMS) or SCADA network via 4–20 mA output or Modbus, the MP5 enables automated alarms when residuals fall below configured thresholds. Operators receive immediate notification — not a delayed report — and can take corrective action before conditions become dangerous.

DEPLOYMENT ADVANTAGE

Because the MP5 has zero ongoing reagent cost, facilities can afford to deploy sensors at multiple critical control points — hot water returns, distant risers, cooling tower basins — providing a true residual map of the building rather than a single-point snapshot.

Where to monitor for maximum protection

ASHRAE Standard 188 and the CDC's toolkit for preventing Legionnaires' disease both emphasize the importance of monitoring disinfectant residuals at points where Legionella risk is greatest. The following monitoring points are recommended for comprehensive building water Legionella prevention:

Hot water system

The hot water recirculation return is the single most important monitoring point. Water returning to the heater represents the lowest-residual, highest-age water in the system. If adequate residual is maintained at the return, it is generally maintained throughout the hot water loop. Deploy an MP5 on the recirculation return line with alarm setpoints at the facility's minimum residual threshold (typically 0.2 ppm free chlorine or the monochloramine equivalent).

Distal outlets

The farthest fixtures from the treatment point — often on upper floors or in low-use wings — represent the highest-risk locations for residual decay. Periodic monitoring at distal outlets, either with portable handheld instruments or permanently installed sensors, validates that the distribution system is maintaining adequate residual throughout.

Cooling towers

Cooling towers are well-documented sources of Legionella outbreaks. Continuous monitoring of biocide levels in the tower basin ensures that treatment chemical concentrations remain in the effective range despite evaporative losses, blowdown, and variable heat loads.



Figure 1. The Halogen MP5 sensor provides continuous, reagent-free chlorine monitoring suitable for building water applications including hot water returns, cooling towers, and distribution system monitoring points.

Standards are moving toward continuous monitoring

The regulatory and standards landscape for Legionella prevention is evolving rapidly, with increasing emphasis on proactive, continuous monitoring rather than reactive testing after outbreaks:

ASHRAE Standard 188 (Legionellosis: Risk Management for Building Water Systems) establishes the framework for water management programs and explicitly requires monitoring of disinfectant residuals as a critical control measure. While it does not mandate continuous monitoring, the standard's emphasis on "control limits" and "corrective actions" aligns naturally with continuous measurement.

CMS Requirement (2017) mandates that all Medicare- and Medicaid-certified healthcare facilities develop and maintain water management programs to reduce Legionella risk. Compliance requires documented monitoring and response procedures.

New York State regulations require cooling tower registration, quarterly Legionella testing, and continuous biocide monitoring — one of the strongest state-level mandates in the country.

The trend across all jurisdictions is clear: from reactive culture testing toward proactive disinfectant residual monitoring. Continuous monitoring positions facilities ahead of this curve and provides the documented evidence of ongoing compliance that regulators and insurers increasingly expect.

C O N C L U S I O N

From snapshots to continuous visibility

Legionella prevention comes down to a simple principle: maintain adequate disinfectant residual at all points, at all times. Grab-sample programs inherently cannot achieve this — they provide snapshots separated by long periods of blindness. Reagent-based online analyzers can provide near-continuous data, but their ongoing consumable costs and maintenance burden limit deployment to a small number of points.

The Halogen MP5's reagent-free, self-cleaning amperometric technology changes the economics of continuous monitoring. With zero consumable cost per measurement point, facilities can afford comprehensive coverage — monitoring every critical control point rather than choosing which risks to leave unmonitored. Combined with automated alerting and BMS integration, this approach transforms Legionella risk management from a periodic manual exercise into a continuous, automated system.

For facility managers, infection preventionists, and water treatment professionals responsible for Legionella prevention, the question is no longer whether to monitor continuously — it's how many points to cover. The MP5 makes the answer simple: all of them.

R E F E R E N C E S

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A B O U T T H E A U T H O R S

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Michael Silveri

Michael Silveri is the founder of Halogen Systems, Inc. and inventor of the company's amperometric sensor technology. With over two decades of experience in electrochemical water quality measurement, he has led the development of reagent-free chlorine analyzers deployed across municipal water treatment plants, building water systems, and industrial applications worldwide.